A JOINT PROJECT BY

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

AND

NATIONAL RESEARCH COUNCIL OF CANADA

PEAT SLURRY PUMPING DEMONSTRATION PROJECT

April 1986

Monenco Peat Group
Carlson & Sweatt-Monenco, Inc.
275 Seventh Avenue
New York, New York 10001

CONTENTS

Section		Page
ABSTRACT		xi
RÉSUMÉ		xiii
ACKNOWLEDGEMENTS		xv
1	INTRODUCTION	1
	A Joint Research and Development Program	1
	Phase 1	2
	Phase 2	2
	Background	3
	The Term "Wet Peat Mining"	3
	Current "Dry" Peat Production	3
	Disadvantages of "Dry" Mining Techniques	4
	Reasons for Interest in "Wet" Mining Techniques	4
	Status of Information on Peat Slurry Rheology	6
2	SITE SELECTION	9
	Site Selection Considerations	9
	Description of Sites Visited	11
	Folley's Bog	11
	Suitability of the Site	12
	Stone Age Humus Packing Company Site	13
	Kowalk Peat Company Site	13
	Suitability of the Site	14
	Bob Murphy Inc. Site	15
	Suitability of the Site	15
	Peatland JJ4-2	17
	Peatland H8-2	17
3	DESCRIPTION OF THE SITE	18
	Area and Shape	18
	Topography and Drainage	18
	Surface Vegetation	18
	Peat Thickness	19
	Peat Types	19
	Von Post Degree of Humification	20
	Laboratory Analyses	21
	Degree of Decomposition	21
	Ash Content	21
	Moisture Content	22
	Other Analyses	23
4	SITE PREPARATION, EQUIPMENT FABRICATION AND ASSEMBLY	32
	Introduction	32

		Page
	Site Preparation	33
	Access Roads	33
	Water Supply Channel	33
	Peat Slurry Reservoir	34
	Test Site Surface Preparation	34
	Layout of the Excavation Site	35
	Equipment Fabrication and Assembly	35
	Support Barge	35
	Valve Skid	36
	Pump Lubrication Water Supply	36
	Hydromonitor Water Supply	36
	Peat Slurry Pipeline	37
	Power Supply	38
	Field Laboratory	38
5	PEAT SLURRY PUMPING TRIALS	42
	Test Objectives	42
	Test Procedure	42
	Mining	42
	Pumping	44
	Mining and Slurry Preparation	45
	Slurry Preparation	45
	Water Pressure/Hydromonitor Range	46
	Water Quantity	47
	Instrumentation and Monitoring	47
	Test Results - Hydromonitor Performance	48
	Peat Slurry Pumping and Pipeline Performance	50
	Instrumentation and Monitoring	50
	Sampling and Analysis	52
	Test Results	52
	Top Layer Peat	52
	Bottom Layer Peat	54
6	ASSESSMENT OF THE DEGREE OF MACERATION	81
	Introduction	81
	Peat Slurry Particle Size Distribution Tests	82
	Objective	82
	Test Procedure	82
	Results	82
	Peat Slurry Settlability Tests	82
	Theory	82
	Objective	83
	Test Procedure	83
	Test Results	84
	Peat Slurry Dewaterability Tests	84
	Theory	84
	Objective	85
	Test Procedure	85
	Test Results	86

		Page
	Discussion of Results	87
	Preliminary Conclusions	88
7	SUMMARY AND FINDINGS	101
8	REFERENCES	111
APPENDIX A	Detailed Analysis of In-Situ Peat	115
APPENDIX B	Site Laboratory Moisture and Ash Results on Peat Slurry Samples	127
APPENDIX C	Data on Monitoring and Analytical Equipment Used at Test Site	129
APPENDIX D	Pump Test Data Sheets	133
APPENDIX E	Calculation Sheets - Pumping and Mining Parameters	157
APPENDIX F	Peat Slurry Pump Estimated Performance Data	161
APPENDIX G	Peat Slurry Settlability Curves	167
APPENDIX H	Peat Slurry Dewaterability Test Data and Curves	177
APPENDIX I	Site Photos	189

ILLUSTRATIONS

Figure		Page
1-1	Peat Slurry Pumping Test Schematic	8
3-1	Baseline Profiles	25
3-2	L35E Sideline Profiles	26
3-3	L65E Sideline Profiles	27
3-4	L80E Sideline Profiles	28
3-5	L95E Sideline Profiles	29
3-6	L110E Sideline Profiles	30
3-7	L125E Sideline Profiles	31
4-1	Plan View - Peat Slurry Pumping Test Site	39
4-2	General Arrangement of Pump Support Barge	40
4-3	Isometric of Control Valve Station	41
5-1	Hydromonitors	65
5-2	Comparison of Hydromonitor Floor Rates Versus Nozzle Pressure for Different Diameters of Hydromonitor Nozzles (USSR Versus Test Data)	66
5-3	Comparison of Theoretical and Actual Water Addition Requirements for 3.7% Peat Slurry Solids Concentration	67
5-4	Pipeline Layout with Instrument Locations	68
5-5	Arrangement of Peat Slurry Pump in Operating Position	69
5-6	Peat Slurry Pump Shop Performance Data on Water (800 rpm, 1" Clearance)	70
5-7	823 rpm, 0.5" Clearance Peat Slurry Pump Performance Characteristic for Different Peat Slurry Concentrations	71
5-8	Comparison of Peat Slurry Pump Performance on Water and Peat Slurry	72
5-9	Pipeline Elevation Profile and Pipeline Pressure Drop	73
5-10	Pump Performance in Peat Slurry With/Without Stump Deflector (3.7% Slurry Concentration, 823 rpm, 0.5" Clearance)	74

ILLUSTRATIONS

Figure		Page
5-11	Comparison of Peat Slurry Pump Performance on Peat Slurry With Previous Russian Pump	75
5-12	Peat Slurry Pump Shop Performance Data on Water (1000 rpm, 1" CLR)	76
5-13	Relation Between Pressure Drop and Peat Slurry Velocity for Different Slurry Concentrations (12" PVC Pipeline)	77
5-14	Pressure Loss Versus Flow Velocity for Different Slurry Concentration (Comparison of Monenco and Swedish Field Tests Data for 12" Pipeline)	78
5-15	Flow Rate Versus Equivalent Length of Pipeline for Monenco Peat Slurry Pump (12" Diameter of PVC Pipeline)	79
5-16	Comparison of the Relationship Between Peat Slurry Viscosity and Solids Content for USSR and North American Peat Types	80
6-1	Graduated Cylinder (Metcalf and Eddy, 1979)	94
6-2	Buchner Funnel Assembly for Determination of Slurry Flexibility (Eckenfelder, 1966)	95
6-3	Peat Slurry Solids Content vs. Specific Resistance	96
6-4	Peat Slurry Viscosity vs. Specific Resistance	97
6-5	Peat Slurry Subsidence Velocity vs. Specific Resistance	98
6-6	Peat Slurry Solids Content vs. Subsidence Velocity	99
6-7	Peat Slurry Viscosity vs. Subsidence Velocity	100
I-1	View of Peatland Prior to Test	190
I-2	Aerial View of Test Site	191
I-3	Slurry Pump in Work Position (Sump)	192
I-4	General View of the Mining Operation	192
I-5	Peat Slurry Preparation by Hydromonitors	193
I-6	Relocation of Hydromonitor	193

ILLUSTRATIONS

Figure	Page
I-7 Control Valve Station	194
I-8 Peat Slurry Pipeline	194
I-9 Peat Slurry Reservoir	195
I-10 Taking a Peat Slurry Sample from the Sump	195
I-11 Taking Peat Slurry Samples for Laboratory Analyses	196
I-12 Peat Slurry Analysis in the Field Laboratory	196

LIST OF TABLES

Table		Page
3-1	Semi-Quantitative X-Ray Spectrographic Analysis of Peat Ash	24
5-1	Water Usage by Hydromonitors	58
5-2	Pumping Test Results for Peat Slurry and Water	60
5-3	Pump Performance Test Results Data for Different Solids Concentrations	61
5-4	Peat Slurry Pump Performance Results on Water and Peat Slurry at Different Clearances	62
5-5	Peat Slurry Pump and Pipeline System Performance and Test Results	63
5-6	Comparison of the Monenco and USSR TPD-4A Peat Slurry Pumps	64
6-1	Partical Size Distribution in Peat Slurry Samples	89
6-2	Peat Slurry Settlability Tests	90
6-3	Subsidence Velocities for Peat Slurries	91
6-4	Specific Resistance of Peat Slurry to Dewatering	92
6-5	Summary of Peat Slurry Physical Properties	93
A-1	Preliminary Sample Analyses Results of the Murphy Site	116
A-2	Moisture and Ash Determinations for Sites 20E, 35E, 65E, 80E, 95E, 110E, 125E and 140E	117
A-3	Preliminary Peat Slurry Viscosity Analyses	122
A-4	Effect of Sample Weight on Final Ash Determination	122
A-5	Effect of Ashing Time on Final Ash Determination	123
A-6	Laboratory Analyses of the Murphy Bog Peat Samples	124
A-7	Basic Composition of Peat	126
A-8	Variation in Conductivity of Peats with Different Ash Content	126
B-1	Site Laboratory Moisture and Ash Analysis on Peat Slurry Samples	128
E-1	Field Data Collected by ORF	158
E-2	Calculated Test Results on Peat Slurry	159
H-1	Peat Slurry Dewatering Test Results	178

ABSTRACT

This investigation by Monenco of peat slurry pumping continues earlier work initiated in Canada under the NRCC National Peat Program and described in reports prepared in 1985 entitled: "Development of Design Parameters for Peat Slurry Pumping and Pipeline Transport", and "Design and Construction of a Peat Slurry Pump/Macerator."

The peat slurry pumping demonstration test included "run-in" testing of the peat slurry pump on a New York peatland site, where both its mining and pumping performance on peat were confirmed on a drained bog. The project consisted of the following stages:

- a site selection process, including a review of six potential peatlands in New York State, to assess their suitability for the peat slurry pumping test;
- a sampling and laboratory testing program to determine the peat characteristics of the test area;
- site preparation activities including access road, construction of a slurry reservoir, water supply reservoir, surface preparation of the mining area and layout of the excavation site;
- equipment fabrication including a barge platform to support the slurry pump, control valve skid and installation of water and power supply systems;
- equipment set-up, including slurry pump, support barge, generator, water pumps, hydromonitors, peat slurry and water supply pipelines;
- mining and pumping activities including peat slurry preparation and pumping tests whereby the actual pump and pipeline performance characteristics were determined based on on-site measurement of the various parameters; and
- studies of the degree of maceration, settability and dewaterability of peat slurry samples taken from various locations in the slurry preparation, pumping and pipeline system.

RÉSUMÉ

La présente étude effectuée par la Monenco sur le pompage des boues de tourbe est la suite de travaux antérieurs entrepris au Canada dans le cadre du Programme national sur la tourbe, qui ont été décrits dans les rapports préparés en 1985 et qui s'institulent : "Development of Design Parameters for Peat Slurry Pumping and Pipeline Transport" et "Design and Construction of a Peat Slurry Pump/Macerator".

Les démonstrations incluaient un essai rapide de la pompe à boues sur une tourbière oligotrophe drainée de l'État de New York, au cours duquel les capacités d'extraction et de pompage de boues de tourbe ont été confirmées. Le projet comportait les states suivants :

- choix de l'emplacement, y compris la revue de six tourbières proposées, situées toutes dans l'État de New York, afin d'évaluer leur pertinence pour l'essai de la pompe;

- échantillonage et essais en laboratoire de façon à déterminer les caractéristiques de la tourbe de la zone soumise aux essais;

- préparation de la tourbière, entre autres : construction des voies d'accès, d'un réservoir à boues et d'un réservoir à eau, préparation de la surface de la zone d'extraction prévue et délimitation du site d'excavation;

- fabrication de l'équipement nécessaire, dont une plate-forme servant à supporter la pompe à boues et un traîneau pour le robinet de commande, et installation des systèmes d'alimentation en eau et en électricité;

- installation de l'équipement, entre autres : pompe à boues, plate-forme, génératrice, pompes à eau, circuit de contrôle de l'alimentation en eau et pipelines à boues et à eau d'alimentation;

- opérations d'extraction et de pompage, c'est-à-dire la préparation des boues de tourbe et les essais de pompage visant à déterminer la capacité réelle de la pompe et du pipeline d'après des mesures de divers paramètres effectuées sur le terrain; et

- étude du degré de macération et de la capacité de décantation et d'essorage d'échantillons de boues prélevés à divers endroits dans le réseau de préparation, de pompage et de transport par pipeline.

ACKNOWLEDGEMENTS

This project was carried out by Monenco's Peat Group by Messrs. G.W. Mankinen (Project Manager), Dr. B.Y. Gelfer (Project Engineer), Dr. E.O. Korpijaakko (Sr. Supervising Biologist), S.S. Banovac (Site Engineer) and J. Riley (Sr. Draftsman). Other Monenco specialist input included Messrs. M. Pildysh (hydraulic design), C. Snejdar (pumping specialist) and J. Penner (electrical). Mr. J. Otar (computer specialist) provided assistance in analysing the test data. The Ontario Research Foundation (Dr. R.G.W. Laughlin and Messrs. B.J. Forrestal and A. Stevenson) provided personnel and monitoring equipment to carry out the work on-site measurements, sample analyses and initial data analysis work.

The authors would also like to acknowledge the assistance of Mr. R. Murphy, President, Bob Murphy, Inc. and Mr. S.J. Otruba of Allis Chalmers Canada, Inc. for valuable assistance during the field trials. On-going discussions and encouragement throughout the project with Mr. J.M. Peterson (Senior Project Manager) of NYSERDA and Mr. T.E. Tibbetts (National Peat Program Manager) of the NRCC was very much appreciated.

SECTION 1
INTRODUCTION

A JOINT RESEARCH AND DEVELOPMENT PROGRAM

During the fall of 1984, the New York State Energy Research Development Authority (NYSERDA) concluded an agreement with the National Research Council of Canada (NRCC) to jointly sponsor a three-phase program of research into peat slurry rheology and the development of a special peat slurry pump/macerator and testing of the unit and the associated mining system. The peat slurry pumping demonstration project is the third phase of the work, and was initiated in early 1985.

Studies of wet peat mining methods were started by the NRCC in 1982 as part of a research effort to complement activities in the peat processing and dewatering technology sector with the development of information and methods on how to prepare and transport peat in a slurry form. High pressure water jets (hydromonitors) and peat slurry pump/macerators have been used previously in the USSR on a large industrial scale, for over 40 years, to extract and pump peat in a slurry form. The reader is referred to the report "Evaluation of Alternative Wet Peat Mining Systems" by Monenco (1983) for further information on the previous USSR wet peat mining experience. In the report, Monenco recommended utilization of the previous USSR experience as a basis on which to develop a peat slurry pumping technology for North American use, rather than possibly "re-inventing the wheel."

Following the inventory of New York State peatlands in 1981, NYSERDA commissioned other peatland studies of environmental matters related to peatland development and investigations of dry peat mining techniques. NYSERDA expressed considerable interest in the NRCC work and decided to join a co-operative effort of investigations of wet peat mining methods.

The three-phase jointly supported research and development program has included:

Phase 1

The first phase was completed in 1985 and was described in a report entitled "Development of Design Parameters for Peat Slurry Pumping and Pipeline Transport." Laboratory methods for determining degree of decomposition of peat and peat slurry viscosities were outlined. A correlation was made between Russian and North American peat and peatland types, since all the USSR data referred to peat classified using the USSR systems. Laboratory testing of peat samples from New York, Saskatchewan, Ontario and New Brunswick were carried out, and a comparison was made of the results to the previous USSR information. Finally, the report included several methods for calculating the main peat slurry pumping parameters, based on an intimate knowledge of the peat characteristics. A computer program was developed to assist in carrying out the rather detailed calculations.

Phase 2

The second phase of the program involved a review of the various designs of peat slurry pumps, numerous discussions with North American, European and Japanese pump manufacturers, preparation of a new design of peat slurry pump and fabrication of same. Monenco engineers worked closely with a Canadian pump manufacturer in preparing detailed designs of the peat slurry pump. The construction of the prototype peat slurry pump/macerator was completed in 1985 and the unit was shop tested on water. Pump performance on water exceeded the design requirements (2000 to 4000 USGPM). The peat slurry pump has several unique features including an external propeller to repel roots, stumps and other debris and an internal macerating unit to prepare the peat, with a minimum energy input, into a form which renders it most suitable for pumping and pipeline transport and fuel production.

The final phase of the program was a field test of the peat slurry pump/macerator at Vestal, New York during summer, 1985. Figure 1-1 is a schematic

diagram of the pumping test layout. Besides determining the performance of the pumping and pipeline system, the field test served as a demonstration of wet peat mining technology, including an evaluation of the effectiveness of preparing slurries using hydromonitors (high pressure water jets). An important parameter regarding pumping and pipeline transport was the maceration of the peat, and it was studied throughout the mining and pumping system.

The following report describes in detail the results of the field demonstration tests carried out at the New York peatland site, with emphasis on the performance of the peat slurry pump/macerator and pipeline system.

BACKGROUND

The Term "Wet Peat Mining"

The term "wet peat mining", refers to extraction methods used to remove peat from a peat deposit, usually in the form of a slurry, by pumping and pipeline transport.

Current "Dry" Peat Production

Currently, almost all large-scale production of peat is by dry mining methods, i.e., use of a drained bog, milling of a very thin surface layer, solar-drying of the milled layer, collection of the dried material and storage in stockpiles. It is estimated 150-190 million tonnes annually of air-dried peat is currently produced in the USSR, using almost exclusively dry peat mining techniques. Although it is almost impossible to locate reliable employment figures for the Russian peat industry, Monenco estimates that at least 20,000 people are employed in the industry in the USSR, and in all likelihood, considerably more. Finland produces approximately 4 million tonnes of peat annually, and employs 2,500-3,000 people directly. Irish production is approximately 5-6 million tons per year (using dry mining techniques) and employs approximately 4,000-5,000 people in the peat industry. The abovementioned statistics apply to total peat production including horticultural,

agricultural, fuel peat, etc. U.S. production is about 800,000 tons of air-dried horticultural peat. The Canadian horticultural peat industry produces approximately 400,000 tonnes of air-dried peat per year and provides employment for approximately 1,200 people in the peat industry.

Disadvantages of "Dry" Mining Techniques

The main disadvantage of dry peat mining is the short harvesting season, during which operations are highly dependent on weather conditions to achieve targetted production goals. The production season usually starts some time in May and lasts until the end of August or possibly into early September, at most northern U.S. and Canadian locations. During this period, weather can create havoc with production schedules. An example can be taken from the Finnish experience of 1981, where the peat production was only 42% of that of 1982. Although research is being carried out in weather forecasting techniques to assist in peat production planning, problems of peat supply in years of bad weather is still a major drawback of the current dry mining methods.

Dry mining methods currently in use require large production field areas. Yields per hectare vary, but a recent Monenco study for a 100,000 tonne per year fuel peat operation showed that up to 1,100 hectares of active mine area (excluding stockpile, roads, and other installation areas) could be required. The study was for a fuel peat operation to fuel a pulp and paper facility, so the size mentioned above is modest if one considers large-scale, peat-fired, thermal-electric power plants.

Reasons for Interest in "Wet" Mining Techniques

Wet peat mining has the advantage of prolonging the production season from the approximately four month period available for dry peat mining to about 9-10 months, for most northern U.S. and Canadian peat production locations. Wet peat mining is considerably less influenced by weather conditions.

It is estimated that wet peat mining would require approximately 10% of the active mining area, compared to dry mining methods, even when used on a drained peatland area. The active mining area required for wet mining on an undrained peatland would be even less.

Wet peat mining can also be considered if drainage of the peatland area is not possible, or difficult. Wet peat mining methods can be used on drained and undrained peat deposits.

Depending on the mining system employed, some wet peat mining techniques are well suited to peat deposits having a high stumps or wood content since water-jets can effectively wash the peat from the wood debris. Wood often causes considerable problems with conventional dry mining equipment, and the inclusion of woody remnants can detrimentally affect the final quality of the peat product.

Although the advantages of wet peat mining techniques are obvious, the question is, "why isn't peat being used in slurry form?" An answer is that it was for many decades in the USSR. Production in the 1950's peaked at about 11 million tonnes of air-dried peat annually; however, production ceased in the early 1960's due primarily to the heavy manual labour requirement on the drying fields required to manipulate the slurry pipeline network for slurry spreading, and the slow solar-drying process itself, which rarely allowed more than 1-2 "harvests" per season. Dry mining techniques have proved more effective in the temperate zones than wet mining techniques when solar-drying is the only means of dewatering to prepare the dried peat product.

With the recent interest in peat in North America, there has been an extensive effort to develop peat mining and processing systems that could improve on the problems associated with dry mining. As a result, there has been considerable effort in the development of peat processing technology which accepts peat in a slurry form. A number of firms offer technology, reported to be at a state of commercial readiness, for processes accepting peat slurry feedstock, and considerable research and development is ongoing in the U.S.A., Canada and Europe on novel methods and improved peat dewatering processes.

Manufacturers of peat de-watering presses also claim to be able to obtain good results on the de-watering of horticultural-grade peats. These developments have caused considerable interest by horticultural peat producers in the development of wet peat extraction techniques and slurry pumping methods and equipment.

Wet peat mining has been carried out sporadically at various locations in the USA during recent years, mainly using small dredging equipment. A wet peat mining operation was in production for a number of years in southern British Columbia, but was apparently recently discontinued due to increasing costs. This operation used a clam-shell mounted on a barge to extract peat, which was then pumped to a peat dewatering press. The resultant, semi-dried peat was transported in bulk to the USA for sale. Monenco visited the operation on several occasions, and examined the mining process in detail including costs. It appears that one of the main problems was the inability of the mining operation to produce a slurry in excess of about 1% solids by weight, as well as problems caused by the considerable amount of roots and other woody debris present. Another wet peat mining operation in Alberta recently reported producing a 1% solids concentration by weight slurry.

Depending on local conditions, it was expected that a wet mining system, developed specifically for peat, could be expected to improve the solids concentration level significantly, hence increase production and reduce costs.

Status of Information on Peat Slurry Rheology

Based on Monenco's investigations over the last 3-4 years, and also on the independent findings of others (e.g., the 1982 Dravo Engineers report on wet peat mining by cutterhead suction dredge carried out for the Gas Research Institute of Chicago, Illinois), there has been virtually no information available on the behaviour of peat in slurry form, in western countries.

The multi-volume Dravo report was an extensive engineering feasibility assessment carried out for a proposed large-scale peat development for a Minnesota location. Although reference was made to the USSR "hydropeat" wet peat mining method, their final comments in the report were as follows, quote:

> "One major problem encountered in the slurry pond harvesting system design has been the lack of information on the slurry pumping characteristics for peat. Considerable time was spent researching literature on this subject without success."
>
> "The peat slurry concentration could be varied during harvesting by changing the dredge cutting rate. To determine the economics of varying the system to pump a thicker slurry, and method for estimating friction losses was developed. For lack of better information, paper pulp data reported by Cameron Hydraulic Data, Goulds Pump Manual, and the Hydraulic Institute Data Book was used as a basis for developing head losses" unquote.

In addition to the recent work carried out by Monenco on peat slurry rheology sponsored by NYSERDA/NRCC, there has been some work also undertaken by Finnish investigators. Information is limited, but it appears that they have not concentrated on the mining technology, but rather on the "pumpability" aspects of peat slurries. Apparently, peat was excavated in bulk, processed in a high-energy input macerating device off-bog into a very "soupy" form, and then various pumping tests were carried out on the material.

Although there has been a lack of information in the west on peat slurry pumping characteristics, this is not so for the USSR. Peat was pumped in slurry form for many decades and a considerable amount of statistical data on peat slurry pumping exists there, as well as information on the design of various mining systems and specially-built peat slurry pumps which were used to transport the peat slurry by pipeline for long distances, up to about 30 km. Monenco had access to a considerable amount of information on peat slurry pumping from this source.

monenco

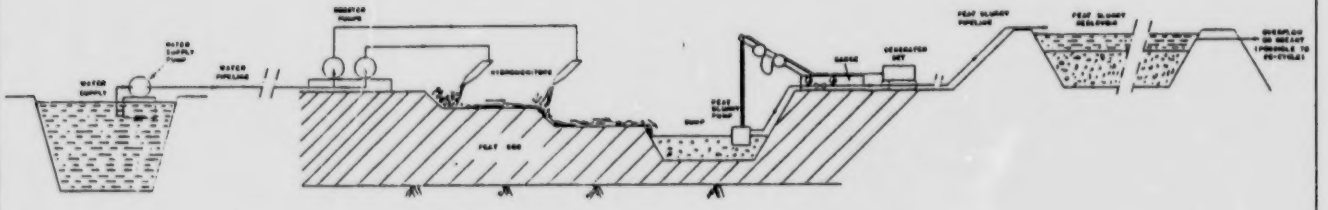


FIGURE 1-1 PEAT SLURRY PUMPING TEST SCHEMATIC

Section 2
SITE SELECTION

SITE SELECTION CONSIDERATIONS

Six peatland areas in New York State were visited to assess their suitability for the peat slurry pumping test. Each peatland was examined to determine the peat and peatland characteristics, location, water supply, infrastructure, owner's interest, etc. The following requirements were considered to determine the suitability of the site for testing of the peat slurry pump/macerator:

- surface area - at least 3 to 5 acres (1.2 to 2 ha);
- peat layer thickness - a minimum of 7 feet (2.1 m);
- drainability - the test site to be drainable or the drainage controllable, depending on the in situ peat moisture content;
- surface cover - the test area not to be heavily wooded, to avoid the necessity of the costly removal of trees, stumps etc.;
- ash content - within the range acceptable for fuel grade peat;
- degree of decomposition - depending upon the nature of the deposit, the desired degree of decomposition of the peat not less than 15% on average (von Post not less than H4 to H5) for a highmoor or a transitional moor peatland and not less than 20% on average (von Post not less than H5 to H7) for a lowmoor peatland;
- stump content - for highmoor and transitional moor peatlands, the stump content (on average) not to exceed 1.5% and on lowmoor-type peatlands the stump content should not exceed 3 to 4%; and
- moisture content - for the test, it was considered that an in-situ moisture content of 86 to 90% was required, to replicate USSR conditions.

More general criteria regarding the peatland setting were also considered, including:

- o access - the need for clearing, road construction, etc.;
- o water supply - the existence of an ample supply of water nearby for the hydromonitors;
- o slurry reservoir - an area close to the test site was required for a reservoir to contain the peat slurry;
- o elevation - reasonable elevation differences between both the surface of the mining area, the water supply reservoir and the slurry reservoir were required to be compatible with heads developed by the water supply and peat slurry pumps; and
- o environmental impact - performance of the test should have a minimum impact, not only the peatland but also on the surrounding area. To minimize lengthy environmental permitting procedures, the site selected should not be environmentally sensitive.

Other site selection criteria used included the local availability of power, skilled and semi-skilled labor (for fabrication and equipment operation), fabrication facilities and rental equipment and services. As well, the property owner's interest and compatability with the project's objectives and potential interference to/by neighboring property owners were assessed.

Delays in implementing the project until late fall/early winter (1984/85) made consideration of virgin peatland test sites difficult, due to the requirement for a drained peatland for the subsequent summer (1985) and for environmental and other permitting reasons. It was decided, therefore, to focus attention on peatlands already in operation or which had been previously developed, although several virgin peatland sites were also visited. The sites considered for final selection included:

- o the Folley property near Syracuse, New York;
- o the Stone Age Humus Packing Company property near Armonk, New York;
- o the Kowalk Peat Company property at Branan Corners, south of Amsterdam, New York;
- o the Bob Murphy Inc. peatland at Vestal, New York;
- o Peatland HH8-2 located within the Fort Drum Military Reserve; and
- o Peatland JJ4-2 near Lisbon, New York.

Brief descriptions for each site, including a review of the advantages and disadvantages of each, is included in the following section.

DESCRIPTION OF SITES VISITED

After a review of the literature on peatlands in the State of New York, six potential test sites were visited. The characteristics and suitability of each one are discussed briefly below, as well as the reasons for the final selection.

Folley's Bog

This deposit is located about 10 miles northeast of Syracuse. It is composed of two basins which are about 3-4 acres in size and are typical mixed- hardwood swamps as far as the surface vegetation is concerned. The trees on the deposits reached the size of merchantable timber. Also on the bog surface there were a number of dead trunks.

The deposits are located in depressions in a rural-residential area, i.e., a number of homes and cottages were nearby. Access to the deposits was excellent and a suitable peat drying area was close by. The average maximum peat thickness was found to be about 10 ft (3 m); the peat was forest peat composed of wood-sedge and sedge-sphagnum with a degree of humification of H5 to H6. The in-situ moisture content was 92.5% and the ash content 2.7%. The ash content appeared abnormally low in comparison with other deposits (on average about 10%) sampled in the State.

The deposit was a typical, small, mixed-hardwood swamp, very common in the State. The use of the site for the slurry pumping test was considered, except that its location in a semi-residential area was expected to possibly pose environmental/aesthetic problems (e.g. noise). The pumping and discharge of waters required in the slurrying process were also considered potentially environmentally sensitive at this location (permitting aspects, nearby lake and cottagers), and the removal of the trees from the deposit may have been considered objectionable to some local residents, as well as the formation of a pond.

The deposit was not considered large enough to support future commercial peat production activities, although it was adequate for the peat slurry pumping test.

Suitability of the Site

In summary, the advantages of the site included:

- satisfactory peat depth;
- low ash content;
- suitable degree of decomposition;
- contained wood to enable proper testing of the stump deflector;
- privately-owned, and the owner was interested in the project;
- located close to a major city with all the technical support facilities;
- water supply appeared to be adequate;
- suitable drying area available; and
- the bog was in a natural state.

Some disadvantages were:

- tree cover was possibly too dense and would have required arduous removal work;
- located in a sensitive area close to residences, i.e., noise, dust, aesthetics of removing the trees and peat may be objectionable, and neighbors may perceive the project to have a land development aspect;
- drainage required;
- relatively long distance and considerable elevation difference between water sources and drying field;
- environmental permitting problems foreseen; and
- due to heavy tree cover, roots and stump content of peat, the test was expected to proceed slowly and result in only a portion of the bog being excavated at the completion of the test. As a result, the site could be left in a rather unsightly condition, i.e., a large hole in the centre of the deposit with considerable debris (trunks, roots, stumps) left. Subsequent reclamation of the site would be expensive and was not allowed for in the project budget, and it was considered unfair to expect the owner to cover such costs.

The most important factor leading to rejection of this site for the test was its location in a semi-residential area where the nuisance of a noisy pumping test was considered to possibly endanger the successful completion of the work, if the local residents raised objections. Also, the effect of the test on the adjacent lake, surrounded by summer and year-round residents posed a potential environmental problem which was judged to have the possibility of requiring time-consuming, costly and perhaps fruitless assessments.

Details of the peat analysis for the Folley deposit were reported by Monenco earlier in the Phase I report (Monenco 1985).

Stone Age Humus Packing Company Site

This site is located near Armonk, about 35 miles north of New York City and about 3 miles by road from Highway 684 in a rural residential area. The peatland is owned by Stone Age Humus Packing Company and peat was being wet mined for the production of potting and greenhouse soils. The peat is well humified (von Post H6 to H7) and composed of typical New York forest peat (a mixture of wood, sedges and sphagnum peat) with some ooze layers. The site is composed of three lakes of 2-8 acres each in size, formerly filled by peat but, at the time of the site visit, partly excavated and water-filled.

Due to drainage problems, lack of a suitable area for containing the slurry as well as possible interference with nearby local residents, the site was considered unsuitable for the peat slurry pumping test.

Kowalk Peat Company Site

This site is located near Branan Corners at the junction of Highways 30 and 159, about 10 miles north of Amsterdam and about 30 miles northwest of Albany, New York. Part of the site was used to mine peat for horticultural use. Most of the deposit, which in total was about 20 acres in size, was untouched and covered by merchantable-sized trees, mostly red maple.

The deposit was drained by a stream to the north and encircled by a drainage ditch made by the landowner. The peat is up to 8 ft (2.4 m) thick in the treed portion of the deposit and is composed of typical New York forest-type peat. The degree of humification is about H5 to H7 (von Post). There are layers of mineral soil in the surface peat, in scattered locations. The tree cover is dense (10-15%) with fallen trees on the surface of the bog. The unhumified peat layer is very thin, less than 8 in (0.2 m) in thickness.

Discussions with the owner (Mr. Kowalk), revealed that there was considerable flooding in the spring, but the drainage ditch alleviated the situation quickly. The owner also indicated that an environmental permit would be required to carry out a pumping test.

Suitability of the Site

Some advantages of the site included;

- the site was in its natural state with a tree cover and the peat contained wood;
- the peat appeared to have a low ash content;
- the deposit was privately owned and the owner was interested in participating in the test; and
- a suitable slurry spreading area was also available.

The disadvantages were:

- the peat layer was a minimum thickness;
- the source of make-up water for slurrying could be a problem;
- the drainage had to be investigated further to ensure drainability;
- the site was somewhat remote from workshops and other maintenance facilities; and
- the owner indicated some previous problems with local environmental officials, and a possibility existed that a permit would be required if a peat slurry pumping demonstration were undertaken on this property.

This site was considered unsuitable due to its relative remoteness from major centres, high probability of being environmentally too sensitive and the peat thickness being at the minimum required level.

Bob Murphy Inc. Site

The site is located in Vestal, about 7 miles west of Binghamton, New York on an ancient flood plain on the south side of the Susquehanna River. The site was privately owned by Mr. Murphy of Vestal, and had been used for the production of peat for horticultural use. The bog was the last one remaining on the property; the previous ones having been excavated. The total area of the deposit was 3.2 acres (1.3 ha) of which only about 2.5 acres (1 ha) remained unused. The peat is up to 16 ft (5 m) thick and is composed of a mixture of well humified (H5 to H7) sedge-wood peat with scattered lenses of ooze and coarser mineral matter. Mr. Murphy stated that he had encountered logs and wood previously in the peat. The drilling confirmed this.

For the initial assessment, a set of 1.6 ft (0.5 m) increment samples were taken from the centre of the deposit to a depth of 16 ft (5 m) for moisture content, ash content, degree of decomposition and viscosity determinations. Ash content readings varied from a high of 24.3% (on a wet basis) at the surface (0-1.5 ft) to a low of 4.3% (on a wet basis) at a depth of 13 to 15 ft. The average ash content for the entire profile was 9.1% (on a wet weight basis). The moisture content at the surface was very low (62.3%) reflecting quite dry recent conditions. For the depth interval from 1.5 to 15 ft, the moisture content averaged 82.3% or equivalent to that of a drained peatland.

Some problems were experienced with the laboratory providing the ash analyses for this property; the results were initially provided on a wet weight basis (as opposed to usual dry basis reporting) which resulted in some initial confusion about the ash level at this property.

Suitability of the Site

The advantages of the Murphy site:

- the site was suitable as far as thickness and minimum size was concerned;

- o the access and the location near Vestal, New York, offered easy access to labor, and other infrastrucuture facilities;
- o no shortage of water was foreseen, based on previous history;
- o no environmental problems were foreseen, the surrounding area (400 acres) was owned by Mr. Murphy and extensive gravel operations had already been carried out around the test site and Mr. Murphy had a mining permit for the area;
- o the owner was interested and could supply maintenance, repair, labour, etc. and other facilities; and
- o an adequate slurry impoundment area was available.

The disadvantages were:

- o initial indications of the ash content (wet weight basis reporting) showed the peat was acceptable, whereas later determinations showed that, on a dry ash content basis, the peat was of marginal fuel grade;
- o there were indications that the deposit had a low stump content, somewhat contrary to information provided by the owner;
- o other disadvantages were mostly of an aesthetic nature; the deposit was small, and surrounded by developed industrial operations and thus, not a typical sample of a peatland in its natural setting.

The factors that determined the selection of the Murphy deposit as the test site were its good location in relation to support facilities, the absence of any environmental constraints and also the owner's interest in the test. Since the owner already had a valid mining permit issued by the U.S. Bureau of Mines for the site, it was expected the environmental clearance process would be relatively uncomplicated. This was the case, when appropriate permissions were sought from the EPA.

The Bob Murphy Inc.'s bog was considered as the best overall site, particularly from the research and "first of its kind" aspects of the project. The excellent access, location on private property, available support facilities and the existing mining permit to carry out removal of peat were the main factors affecting selection. The other sites had some form of environmental assessment requirement indicated that could have jeopardized the project schedule and may have even precluded the sites from being used.

Peatland JJ4-2

This deposit is located in St. Lawrence County. It is about 2-3 miles (4 km) southeast of Lisbon and a local paved road crosses its center. It had been surveyed in detail previously and more information is available in the report by Monenco (1982). The entire deposit is over 1000 ha in area and it has a peat layer up to 12.5 ft (3.8 m) thick. As far as the peat thickness, ash content (on average 9.8%) and peat types are concerned, the deposit would have been suitable for testing. However, its remote location, difficult drainage and the requirement for an environmental clearance, as well as the lack of a suitable back-up water reservoir outweighed the advantages, and it was deemed unsuitable for testing.

Peatland H8-2

This deposit is located in Jefferson Country about 10 km south of Intwerp. It is located within the boundaries of the Fort Drum Military Reserve. Its total area is about 300 ha. It is covered by a very dense stand of trees.

Peat was sampled at one location. The thickness was 7.5 m, the overall ash content of a composite sample was 15.7%. While the size of the deposit and the thickness of its peat were suitable for slurry pumping test, the heavy tree cover as well as its location within a military area and remoteness from necessary facilities made it unsuitable.

Section 3
DESCRIPTION OF THE SITE

AREA AND SHAPE

The Murphy site had been previously used for peat mining and only about 2.5 acres (1 ha) of usable peatland remained. The total area of the site, including the partially mined out edges, is 3.2 acres (1.3 ha). The site is roughly oval in shape, its longest axis is in an east-west direction being about 525 ft (160 m) and greatest width is in a northeast-southwest direction, about 300 ft (90 m).

TOPOGRAPHY AND DRAINAGE

The deposit is essentially flat without any conspicuous gradient or mounds. It is located in a depression in a gravelly fluvial deposit on the southern side of Susquehanna River well above the regular flood level of the river. There was a drainage channel from the western edge of the deposit discharging into the Susquehanna River, but it had been blocked during earlier peat mining operations and was not functional at the time of the mining test. It carried run-off from the adjacent mineral terrain during periods of precipitation.

SURFACE VEGETATION

The surface vegetation was composed of a great variety of local herbs, rather than wetland vegetation, due to the drainage the deposit had been subjected to. There were no trees and few shrubs on the surface and, consequently, no surface vegetation removal for the test was needed.

PEAT THICKNESS

The peat layer was drilled by a Hiller auger at 27 locations on the deposit to study peat type, thickness and degree of humification. Laboratory samples also were taken with a piston sampler at most locations. The maximum thickness was 16.1 ft (4.9 m) and the average at the sites drilled was 15.1 ft (4.6 m). The thickness at these sites varied from 13.8 to 16.1 ft (4.2 to 4.9 m). Figures 3-1 to 3-7 show profiles through the site.

PEAT TYPES

The entire deposit is characterized by lowmoor peat types with limited areas where sphagnum is the predominant component of the peat. Due to the past geological history, the peat in this deposit contains quantities of silt or finer mineral matter as thin lenses intermixed with peat or as additional material interspersed in the peat. At the surface, there is a universal cover of very silty peat with a very high ash content (over 60%) to a depth of about 1.3 ft (0.4 m). The high ash content in this surficial layer is a result of extreme floodings by the Susquehanna River during recent years, whereby considerable deposition of sediment has occurred on the bog. In addition, the owner had spread mineral soil on the surface at a few locations to support equipment to carry out sporadic excavation work.

Below the surficial layer, layers of peat dominated by sphagnum were found along the base line to depths varying from about 1.9 to 2.4 m and along the sidelines from about 3.9 to 7.9 ft (1.2 to 2.4 m). Other components in these peat layers included minor quantities of shrub wood (10%) and more prominent sedge family plants (40%).

Below this, there were layers of sedge peat mixed with variable quantities of shrub wood, conifer wood, sphagnum and very fibrous remnants of reeds (Phragmites). The remnants of reeds had a low degree of humification (H2) and together with sedge formed a few scattered layers of very compact and fibrous peat. Reed peat was also the dominant basal peat in a number of locations.

The high variability in the thin peat layers of different peat types did not allow selective mining of any pure peat type layers. The underlying mineral substrate was ooze (see Figures 3-1 to 3-7).

VON POST DEGREE OF HUMIFICATION

All the field determinations of the degree of humification (decomposition) were done by the von Post method, as is commonly applicable to field surveys. The von Post method is a well-established international system used in peatland surveys to determine the degree of humification. The von Post field method has not been correlated to the centrifugal laboratory method (used primarily in the USSR) for determining degree of decomposition due to insufficient data and study. It has been noticed that the correlation appears to vary from one peat type to another and is also affected by other parameters such as ash and moisture content.

The overall average von Post degree of humification for the entire deposit was found to be H6.0. There was no unhumified surficial layer present, although unhumified peat was encountered at varying depths. Most of the deposit is composed of fuel grade peat with a degree of humification of H6.6, for the humified part. There were layers of unhumified peat at 15 of the 27 sites drilled. The layers were located mostly from depths of about 9.2 to 11.8 ft (2.8 to 3.6 m) and at a few other sites from 5.9 to 7.9 ft (1.80 to 2.40 m). From the surface, the balance of the deposit was found to be composed of highly humified peat.

The unhumified layers (H3 or less) are considered an integral part of the past developmental history of the deposit and reflect the changes in the climate and vegetation and the speed of degradation at the time of accumulation. The unhumified peats were mostly composed of quite pure sedge and reed-sedge peats and were very fibrous (see Figures 3-1 to 3-7).

LABORATORY ANALYSES

Degree of Decomposition

Laboratory determinations of degree of decomposition were carried out on peat samples from the test site using the centrifugal method, commonly used in the USSR, and described previously by Monenco (Monenco, 1985). Degree of decomposition is expressed as a percentage (i.e. percentage of structureless or amorphous matter of the total sample).

The % degree of decomposition was determined by the Ontario Research Foundation Laboratory for a total of 14 samples of original, untreated peat. Each sample was a combined sample composed of 2 to 6 sub-samples. For each combined sample, sub-samples from identical depths were taken with peat types of a similar nature. The degree of decomposition varied from 16% up to 24%, averaging 20.1%. The values were slightly lower for the depths of 6.6 to 7.9 ft (2.0 to 2.4 m) (18.25%) and 7.9 to 9.2 ft (2.4 to 2.8 m) (16 and 20.25%) than for lower depths, where results varied from 19.63 up to 24%.

Ash Content

Ash content was determined on 186 individual samples and 12 combined samples. The overall average ash content for the individual samples was 29.2% (on a dry weight basis). This figure includes the very high ash content for the surficial peat which reached values over 60%. It also includes a number of basal peats with high ash content (up to 40%). The average ash content for the combined samples for the intermediate peat layer, between the depths of 6.1 and 13.1 ft (2.0 and 4.0 m) and considered for mining, was 22.9%.

The surficial layer with an average ash content of 56.2% (limits 40.6 to 67.9%) varied from 1.6 to 7.9 ft (0.5 to 2.4 m) in thickness, and averaged about 2.6 ft (0.8 m) over the selected mining area. This layer was pumped out as a slurry before actual pumping tests began, since the high ash content made it atypical and therefore, not suitable for peat slurry testing. The surficial layer was also underlain by another layer, varying from 1.3 to 4.3 ft

(0.4 to 1.3 m) in thickness, with an average ash content of 33.1% - still considered too high for the peat slurry pumping test purposes. This layer in turn was intermittently underlain by a layer up to 2.3 ft (0.7 m) in thickness and having an average ash content of 26.8%.

The layer with the lowest average ash content (18.2%) varied in thickness from 1.3 o 3.9 ft (0.4 to 1.2 m) and was situated below the abovementioned layers at about 6.6 to 9.2 ft (2.0 to 2.8 m) below the surface, down to about 10.5 to 11.8 ft (3.2 to 3.6 m). This layer was considered suitable for the peat slurry pumping test due to its lower ash content. It, in turn, was underlain by the abovementioned layers in a reversed order, making the greater depths again less suitable for peat mining.

The Murphy site had numerous advantages for use as a test site, as explained earlier. However, on an ash content basis, the deposit was considered marginal for fuel peat use (e.g. DOE, 1979 recommended 25% ash as the cut-off value for fuel peat). Therefore, it was decided to concentrate study on the low ash layers of the deposit. It was anticipated that selective mining techniques would be used to isolate such layers for the further studies in the field on pump/pipeline performance.

Moisture Content

Moisture content also was measured on a total of 186 individual samples and average 85.1% (wet weight basis). This relatively low value, in comparison with that of 90-97% for a virgin peatland, reflects the influence of the effects of drainage on the site due to previous activities on the bog and the surrounding terrain. The relatively low moisture level is similar to that encountered at previously drained peatland mining operations and was desirable from standpoint of equipment trafficability and slurry solids concentration control.

Other Analyses

One ash sample was analyzed for its elemental composition. The results are given in Appendix A. The elements with blank boxes were not detected. The ones marked high were analyzed separately, with Si and Al reported to be 15-20% and Ca 10-15%. Otherwise no anomalies were detected. The details of individual sample analysis are given in Appendix A. These include moisture content measurements (% of wet weight), ash content (% of dry weight), viscosity measurements of varying solids content, the effect of sample weight and ashing time on final ash determination, the basic chemical composition of peat and semi-quantitative x-ray spectrographic analysis of the peat ash.

Viscosity and solids content are studied in more detail elsewhere in the report and will not be discussed here. The basic chemical composition of peat at this site was typical of peat of this type in general and the values for C, H, O, N and calorific values were within normal limits. It was interesting to note that the sulphur content at this site was only 0.28 to 0.29%, or similar to that found for peat in Canada, e.g., but lower than that found in other parts of New York where it often was close to 2%, averaging 1.2% (Monenco 1982).

Table 3-1

SEMI-QUANTITATIVE X-RAY SPECTROGRAPHIC ANALYSIS OF PEAT ASH
(values in % of ash weight)

Sodium	0.24	Nickel	0.01
Magnesium	1-2	Copper	0.01
Aluminum	HIGH	Zinc	0.01
Silicon	HIGH	Arsenic	N.D.
Phosphorus	0.15	Bromine	N.D.
Sulphur	0.66	Strontium	0.01
Chlorine	0.01	Zirconium	0.01
Potassium	2-5	Niobium	N.D.
Calcium	HIGH	Molybdenum	N.D.
Titanium	0.40	Silver	N.D.
Vanadium	N.D.	Tin	0.01
Chromium	N.D.	Antimony	N.D.
Manganese	0.04	Barium	0.06
Iron	2-5	Tungsten	N.D.
Cobalt	N.D.	Lead	N.D.
		Rubidium	0.01

N.D. = not detected

FIGURE 3-1

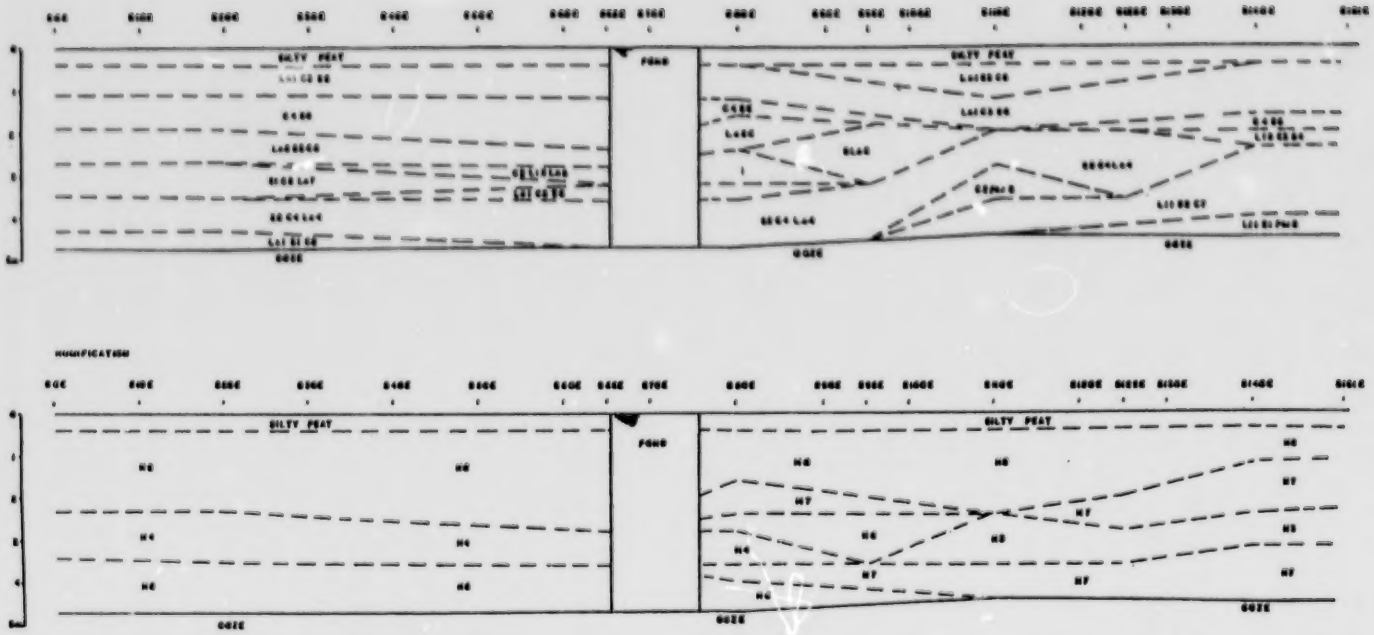


FIGURE 3-2

L35E SIDELINE PROFILES

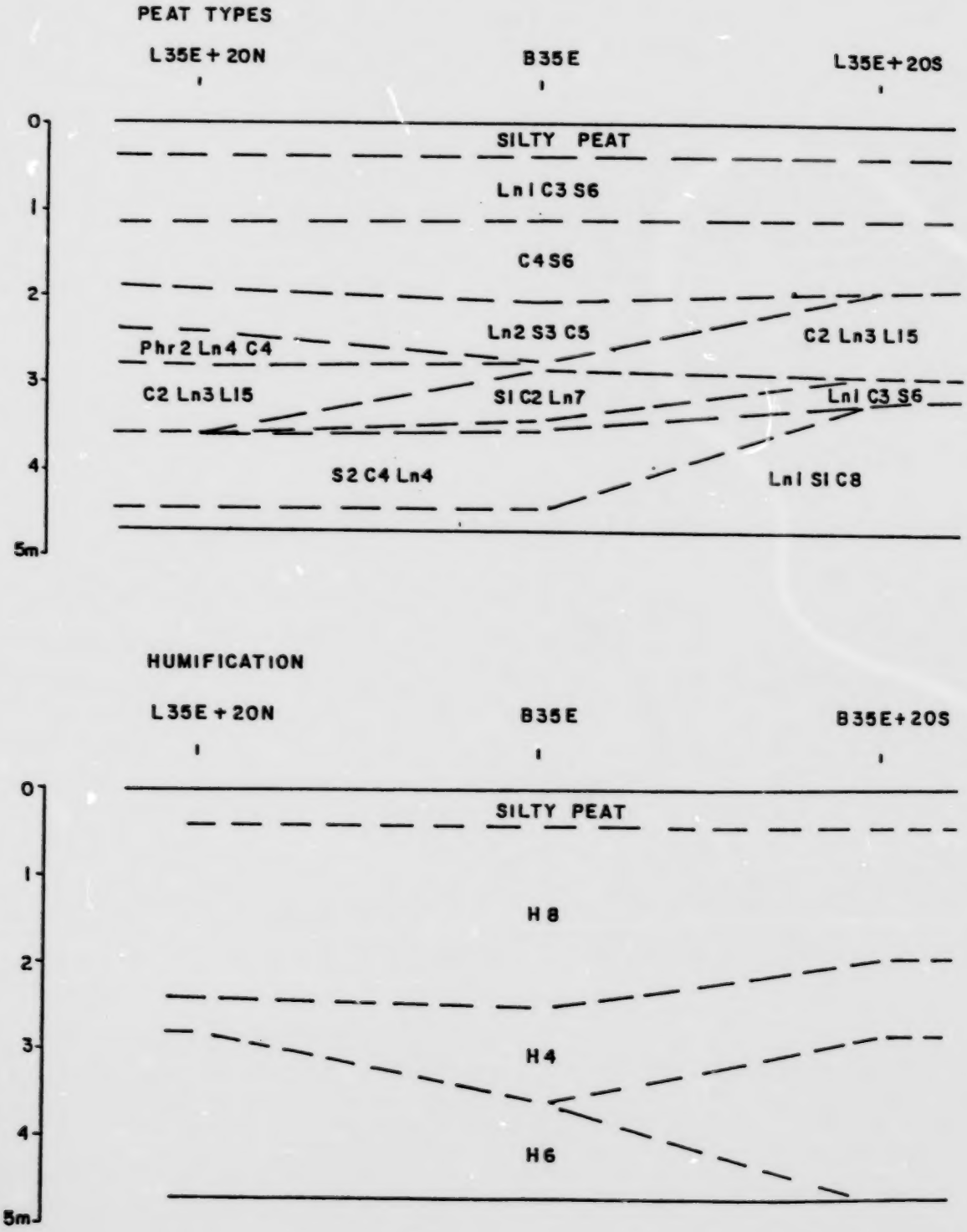
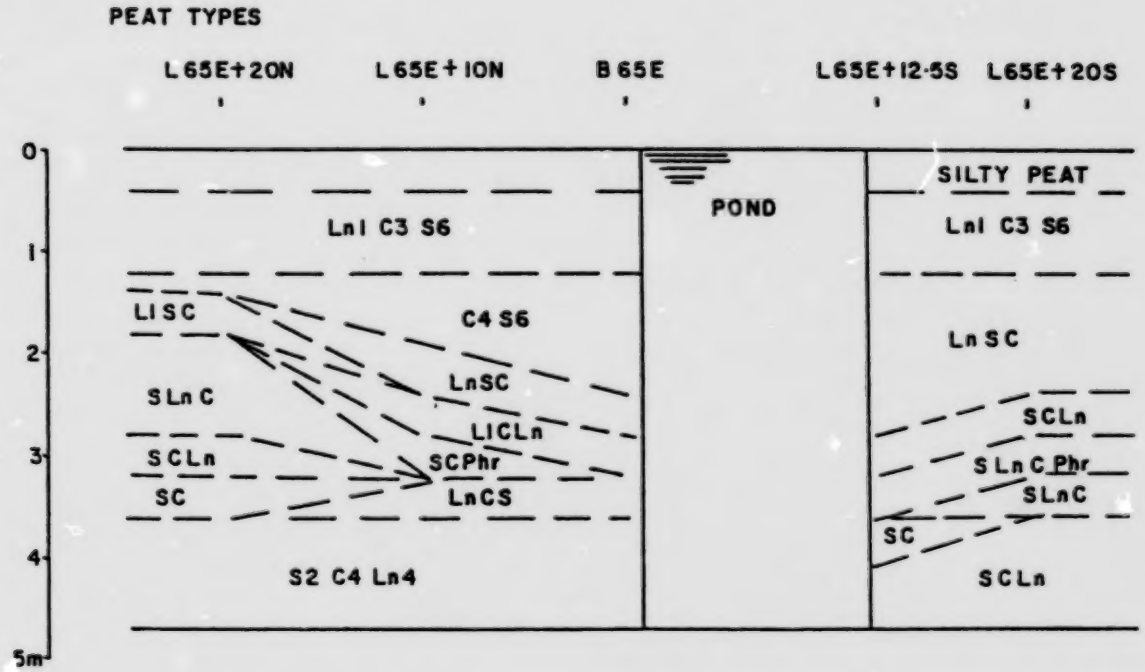


FIGURE 3-3

L65E SIDELINE PROFILES



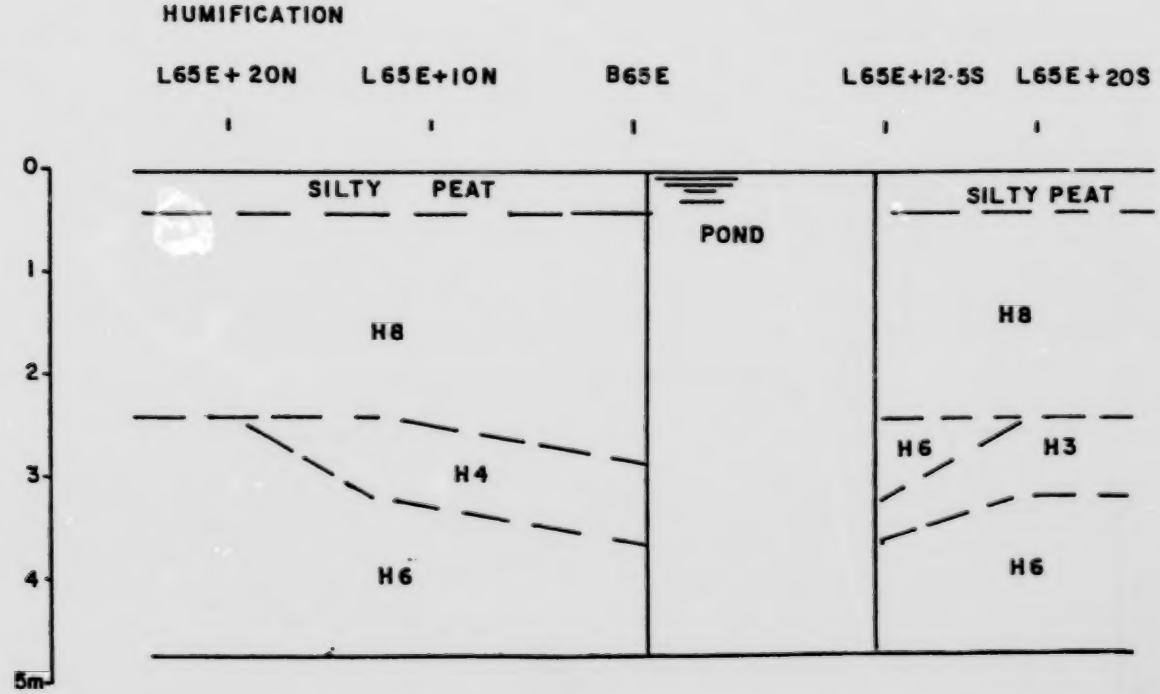


FIGURE 3-4

L80E SIDELINE PROFILES

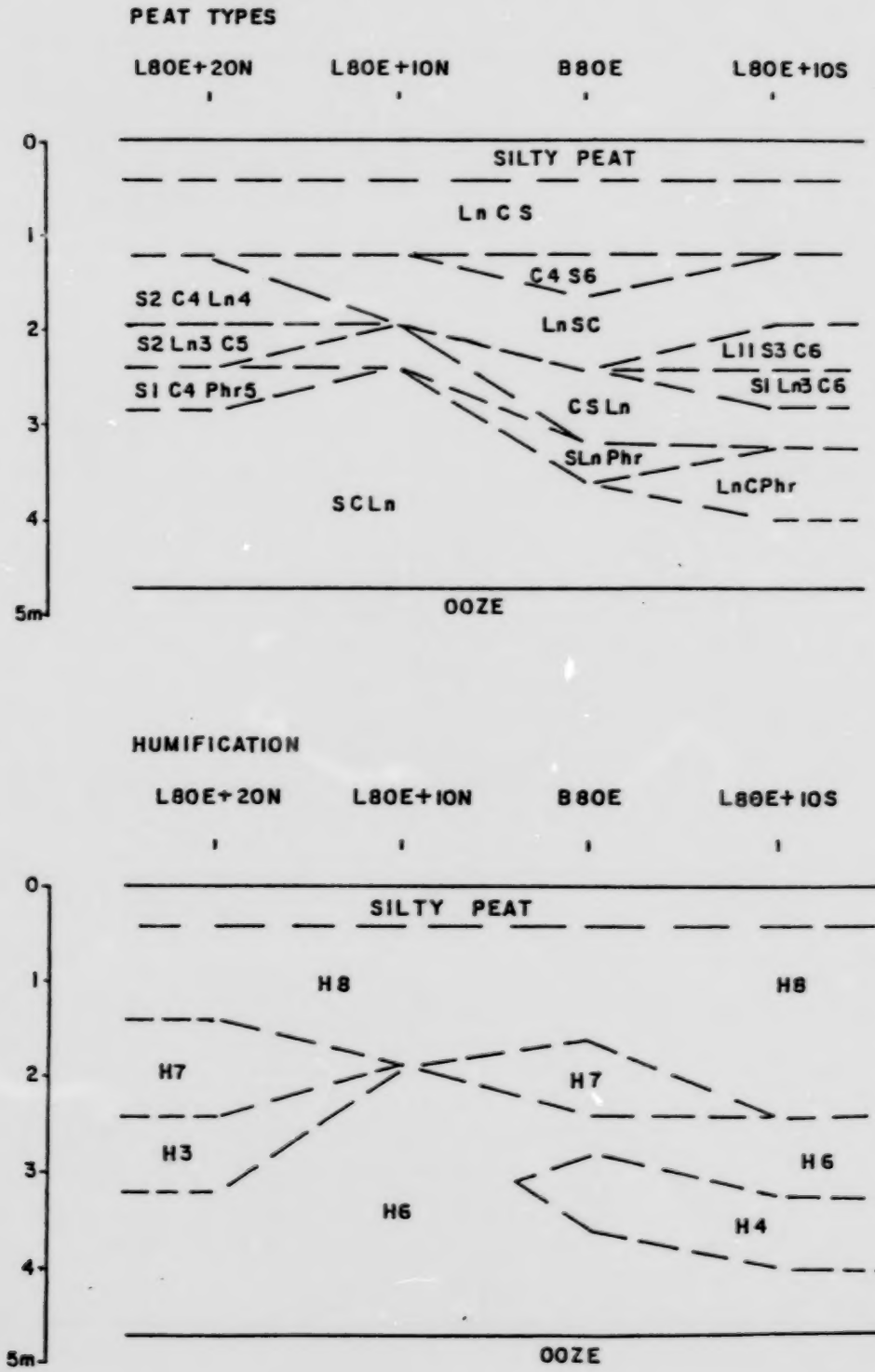


FIGURE 3-5

L95E SIDELINE PROFILES

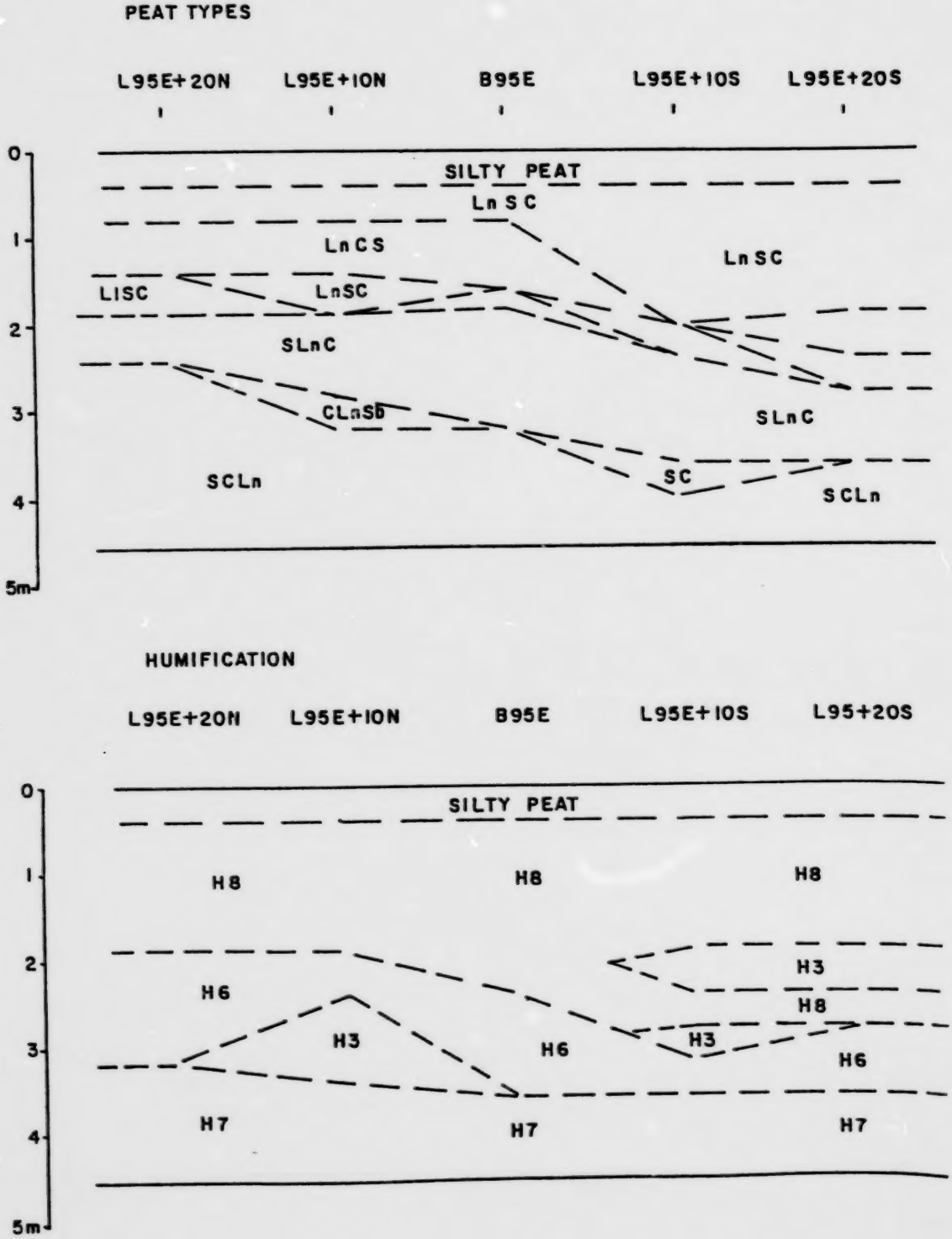


FIGURE 3-6

L110E SIDELINE PROFILES

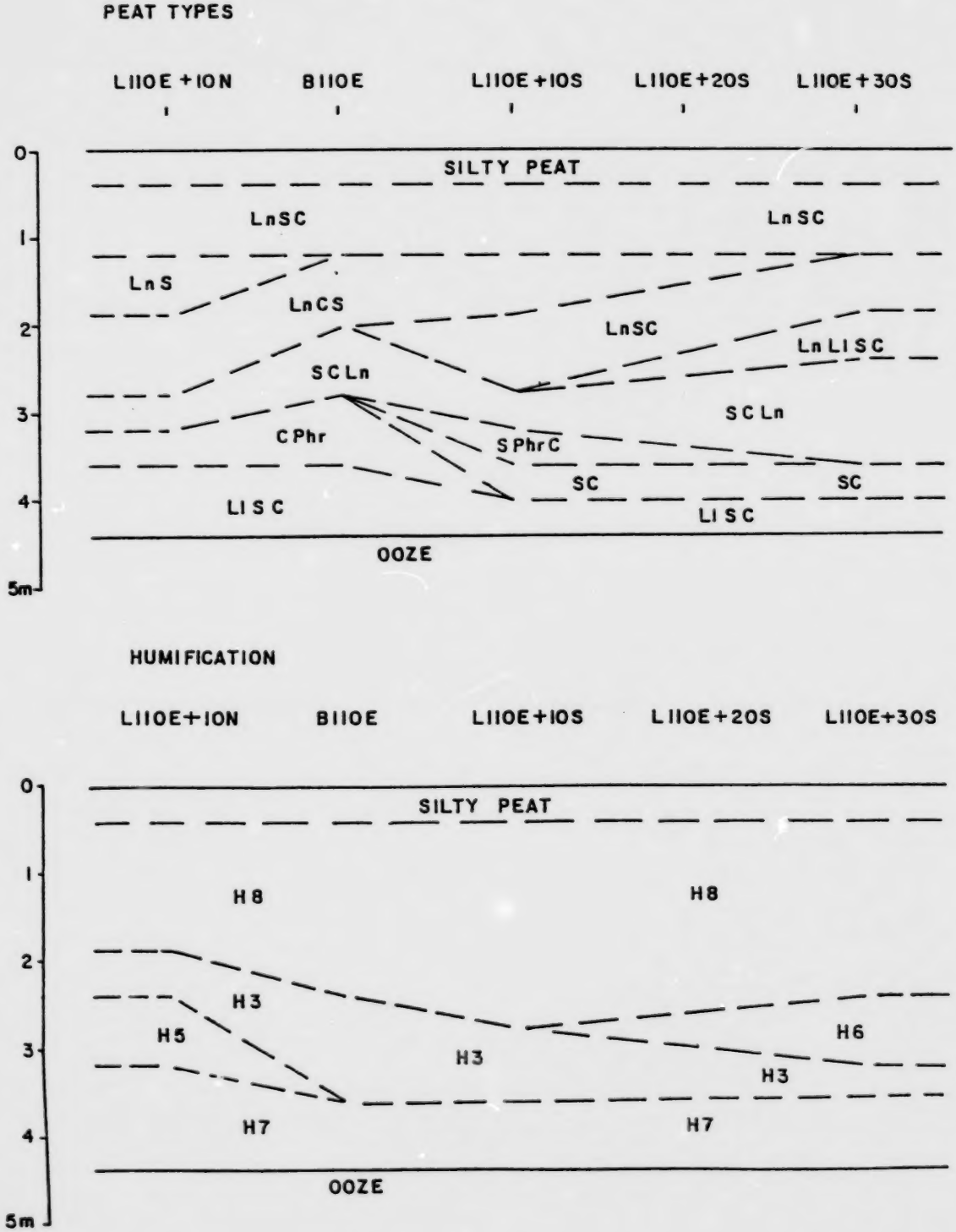
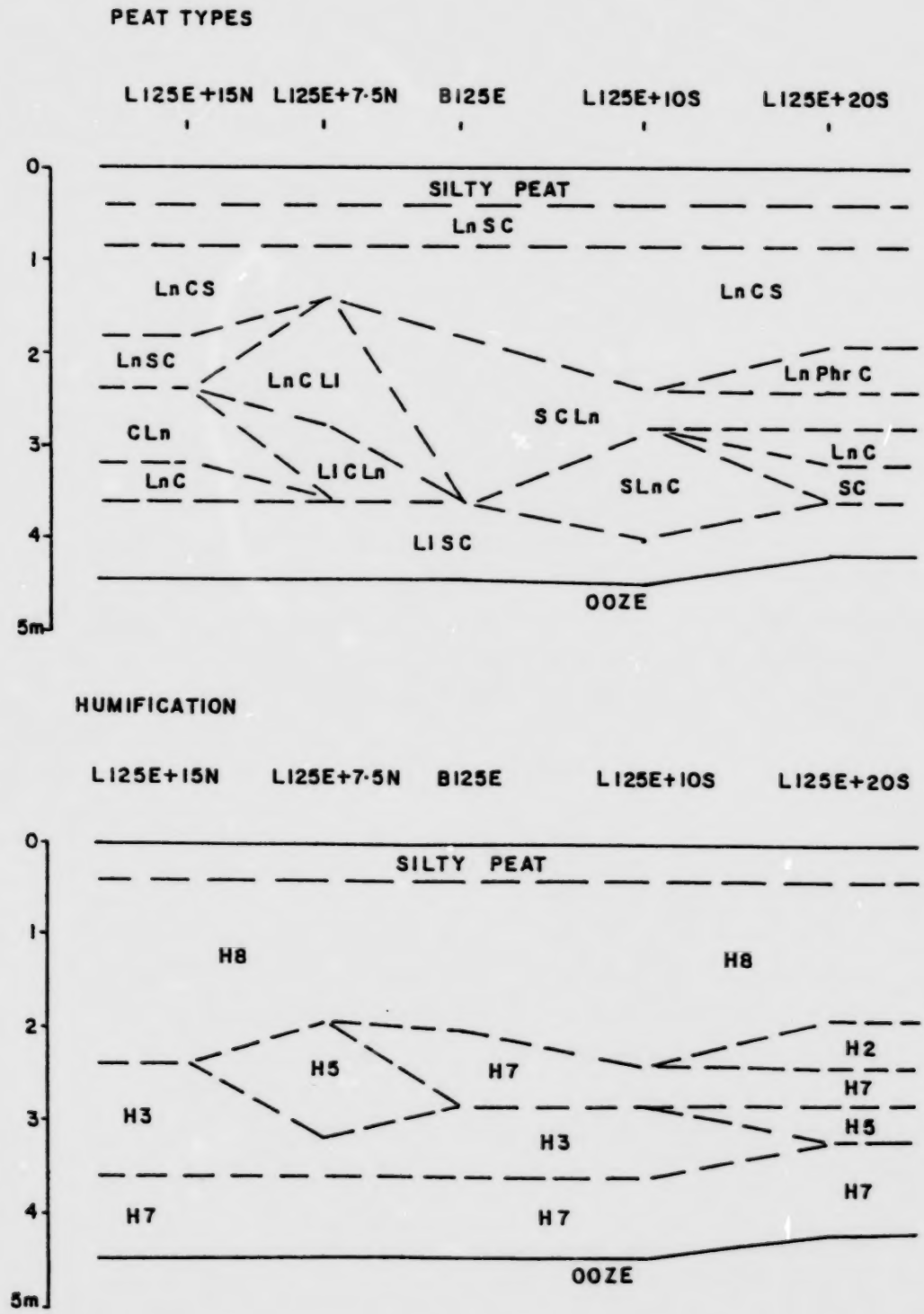


FIGURE 3-7

L125E SIDELINE PROFILES



Section 4
SITE PREPARATION, EQUIPMENT FABRICATION AND ASSEMBLY

INTRODUCTION

Figure 4-1 shows the general layout of the test site in plan view. In effect, two distinct systems exist, the water supply or water addition system and the peat slurry system. Water at relatively high pressure was added to the peat deposit in the area of mining or peat extraction activity, through the hydro-monitor nozzles. Peat slurry was formed and flowed to the sump area and entered the peat slurry pump, where the peat was macerated and then delivered by pipeline to the slurry reservoir area. The property owner planned to allow the peat to settle, decant water from the top layer and eventually recover the peat for a horticultural purpose (although the peat was fuel grade).

To carry out the test, the following site preparation activities were required:

- o upgrading of an access road;
- o excavation of a water supply channel;
- o construction of a peat slurry reservoir;
- o surface preparation of the selected mining area; and
- o layout of the excavation site.

As well, various pieces of equipment had to be fabricated and/or assembled including:

- o fabrication of the peat slurry pump support barge (the largest single equipment item);

- o fabrication and assembly of a control valve skid, the slurry pipeline and discharge spill tank;
- o installation of the hydromonitor water supply system, and the pump lubrication gland water supply;
- o installation of the power supply system; and
- o installation of the field laboratory.

This section describes the abovementioned tasks.

SITE PREPARATION

Access Roads

Accessibility about the test site was good. A paved highway bordered the property and many gravel roads existed around the site due to sand and gravel recovery operations conducted by the owner. It was only necessary to upgrade the roads to give access to the bog on three sides, and once the berms for the peat slurry reservoir were constructed, travel by vehicle was possible completely around the site.

Water Supply Channel

Water needed for the hydromonitors was drawn from a channel excavated in an abandoned gravel pit approximately 100 ft (30 m) north of the peat deposit (see Figure 4-1). The channel was excavated by dragline roughly parallel to the peat deposit and it was approximately 500 ft (152 m) long, 45 ft (14 m) wide, and 7 ft (2.1 m) in depth. It was required to supply a flow of 2000 USGPM (7570 l/min), for a daily maximum requirement of 5 to 6 hours pumping, over the expected 1 to 2 week pumping test period.

Replenishment of the water in the channel was almost entirely from groundwater recharge. Due to the dry weather (drought) conditions experienced during the test, and the resultant drop in the water table level, as well as the large amounts of water drawn during the pumping tests, the channel eventually required lengthening and deepening at the main water supply pump location.

Peat Slurry Reservoir

A reservoir was constructed, adjacent and west of the peat deposit, for containment of the peat slurry during the pumping trials. The reservoir, measured approximately 425 ft (130 m) long by 245 ft (75 m) wide and was about 8 ft (2.4 m) in depth (see Figure 4-1). It yielded a usable volume of about 22400 yd^3, allowing 2 ft (0.6 m) of freeboard. The reservoir was designed to accommodate an inflow of peat slurry of about 2000 USGPM (7570 l/min) for a maximum requirement of 5 hours pumping per day for 7 days.

The berms were constructed from on-site materials, mostly clays, silts and gravels scraped from the floor of the reservoir. This material was compacted by a large bulldozer maintaining a 2:1 wall slope. The existing hillside topography formed natural containment walls along the south and west sides of the reservoir.

A 24 inch diameter pipe was placed in the northwest corner of the reservoir to serve as an overflow diversion, if required. Upon completion, the bottom of the reservoir was approximately at the same elevation as the surface elevation of the bog at the test site.

Test Site Surface Preparation

A perimeter ditch (approximately 10 ft (3 m) wide and 5 ft (1.5 m) deep was in place around the southeastern, southern and southwestern sides of the bog, and the hydrogeology of the site had been altered by previous activity in the general area, resulting in the site being generally well-drained. Moisture content analyses on peat samples from the deposit showed that the interval from surface to a depth of 10 ft (3 m) was within the 86 to 90% range, which provided generally good surface bearing capability and bank stability for the mining pit walls, during the tests.

The surface of the peat deposit was disked prior to moving equipment on site to remove the growth of tall grasses and some shrubs.

Layout of the Excavation Site

Prior to performing the peat slurry pumping trials, the entire mining area (mining pit, trench, sump etc.) was laid out on the bog surface using wooden stakes. Figure 4-1 shows the plan view of the test site. In addition, lengths of 20 ft (6 m) graduated, steel conduit were driven into the trench and mining pit areas, to be used as depth indicators during excavation activities. Depth control was important, particularly in the mining pit area because it was necessary to locate the low ash content peat during mining.

EQUIPMENT FABRICATION AND ASSEMBLY

Support Barge

A barge was fabricated to support the peat slurry pump on the bog surface. It included a winch and boom arrangement to lower and raise the peat slurry pump/macerator into and out of the peat slurry sump. The barge was constructed as shown in Figure 4-2 and was fabricated at the test site.

A double-drum winch and motor was positioned on the rear of the barge and secured. The front end of the barge was suitably reinforced to support a 32 ft (9.8 m) steel boom. The winch cable for raising and lowering the pump was 1-1/8 inches in diameter and several 5/8 inch diameter steel cables were used for supporting the boom, at approximately 45 degrees. Guides were welded onto the side of the boom to support the electric cable feeding the 150 hp electric drive motor on the peat slurry pump.

Upon completion, the barge was 52 ft (15.8 m) long and 17 ft (5.2 m) wide. Prior to being towed into position onto the bog, lift tests were performed to ensure that the winch, cable and boom assembly were functioning properly and could adequately support the weight of the pump and motor while in operation. Two lift tests were performed, one with a weight approximately equal to the pump and motor (about 7000 lbs) (3175 kg) and another at double the weight. All tests were conducted with the boom at a 45° angle.

Valve Skid

A "valve skid" was constructed which formed a control station adajacent to the barge and included two valves to control slurry flow and an air evacuator system (see Figure 4-3). The main purpose of the valves was to control the flow of slurry during pump start-up and stopping operations and to modify the flow conditions in the 12 inch diameter PCV slurry pipeline attached to the discharge end of the skid. The air evacuator system was installed to study possible air entrainment problems in the slurry pipeline, a problem that had been encountered in peat slurry pumping operations in the USSR.

Pump Lubrication Water Supply

The peat slurry pump/macerator was designed to accommodate either water or grease lubrication of the main bearings; however, for cost and simplicity reasons (not a permanent installation) the water lubrication system was chosen for the test. A 5 USGPM (19 l/min) water supply was connected to the pump to provide clean water for lubrication of the main bearings. Details of the peat slurry pump/macerator construction can be found in an earlier Monenco report (Monenco, 1985).

Hydromonitor Water Supply

One of the main preparatory tasks was the assembly of the hydromonitor water supply system. The main components of the system included a main water supply pump (low pressure), two jet pumps (high pressure), lengths of 10-inch diameter steel pipe, and two separate runs of 6-inch diameter steel pipe, rubber hose and the two hydromonitors.

A 10" X 10" wellpoint pump (main water supply pump) was used to draw water from the water supply reservoir. The pump was skid-mounted and set on the deck of a barge, and was allowed to float in the water supply channel. To keep debris out of the high pressure pumps, a strainer was attached to the suction end of the pipe feeding the tank on the wellpoint pump's vacuum system. From the wellpoint pump, water at a rate of 2000 USGPM (7570 l/min)

was conveyed to the 2 high pressure pumps, a distance of approximately 100 ft (30 m). The skid-mounted high pressure pumps were located on the deposit, and also placed on a pontoon barge (see Figure 4-1) for ground support reasons. Both the wellpoint pumps and the high pressure jet pumps were powered by diesel engines.

From the high pressure pumps, the water was pumped to each hydromonitor approximately 200 to 270 ft (61 to 82 m) (depending on mining activities) by the combination of 6" steel pipe and rubber hose. The flows and pressures at the pumps and at each hydromonitor were measured by flowmeters and pressure gages placed at the discharge end of the jet pumps and on the hydromonitor nozzles.

Peat Slurry Pipeline

Another important preparatory task was the assembly of the peat slurry pipeline. From the valve skid to the spill tank located at the end of the pipeline, 860 feet of 12" (inside diameter) PVC pipe was assembled. The individual lengths of pipe were connected, either by cementing (using a PVC solvent, "PVC Welder") the pipes and couplings, or by a friction fit. To resist lateral movements, the pipeline was fastened at the joints with form wire to large wooden spool ends. In addition, a number of joints, particularly the elbows, were covered with small amounts of concrete to improve stability of the pipeline during operation. The pipeline was suitably supported on the ground surface along its entire length by levelling and grading the mineral terrain and providing wooden supports under the portion of the pipeline on the bog surface.

At the discharge end of the pipeline, a cylindrical tank was installed in the western wall of the reservoir to act as a "spill box" and a support for the discharge end of the pipe.

Power Supply

Electrical power to operate the peat slurry pump/macerator was supplied by a GM AC diesel generator set (470 hp, 437 kVA, at 1800 RPM, 3 Phase, 60 Cycle). Energy from the generator set was fed by power cable to a 150 hp Westinghouse, 1800 RPM, 460 V electric motor mounted on the slurry pump. The electrical system included a GE starter (rated at 150 hp, 460 V with 110 V controls). The diesel generator set was located at the northern edge of the bog and a separate stop/start button (to control the peat slurry pump) was mounted on the valve skid, adjacent to the support barge on the bog. A 1500 kW power meter was installed in the power supply circuit to monitor power consumption by the pump.

Field Laboratory

A field laboratory was set up at the test site in an unused building and each day during the pumping trials, representative samples were prepared for moisture, ash and viscosity determinations.

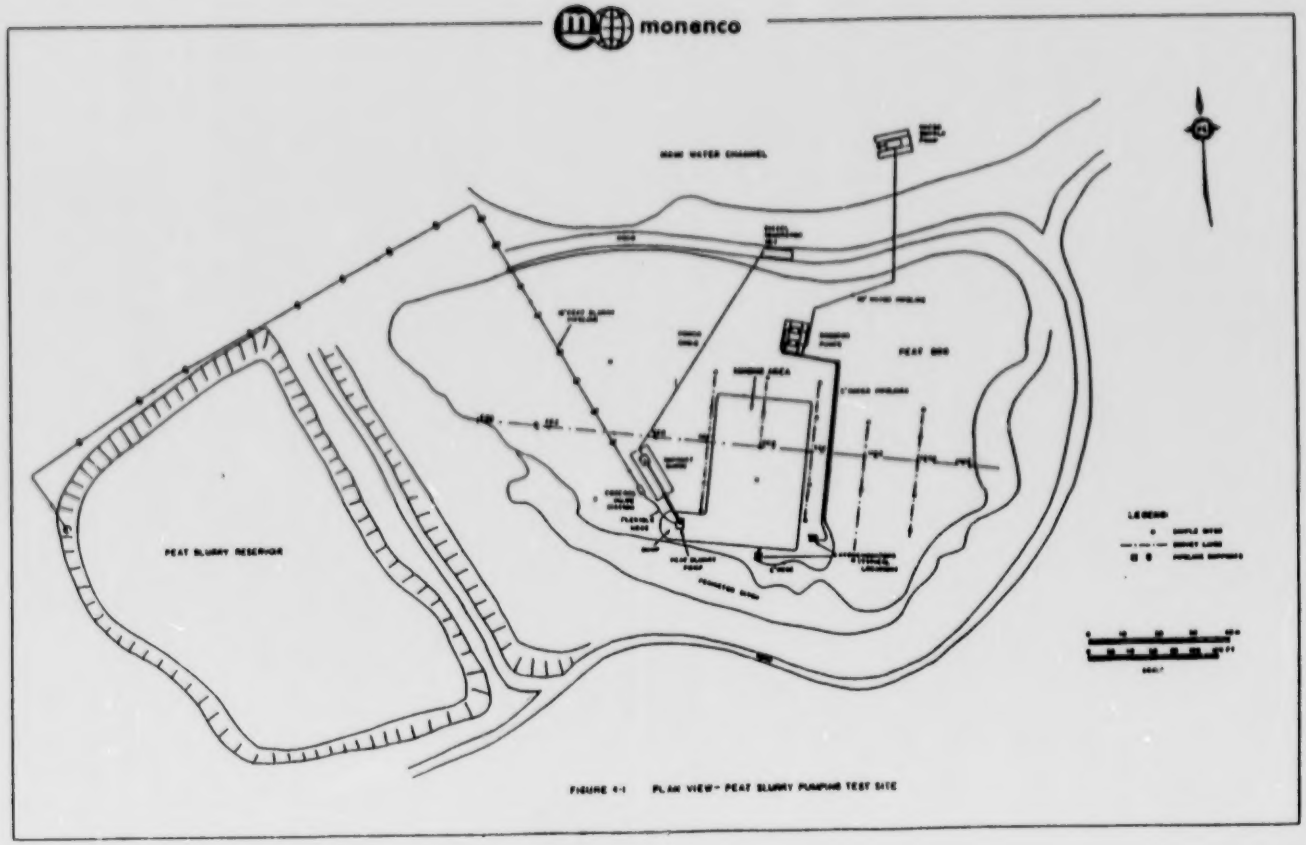


FIGURE 4-1 PLAN VIEW - PEAT SLURRY PUMPING TEST SITE

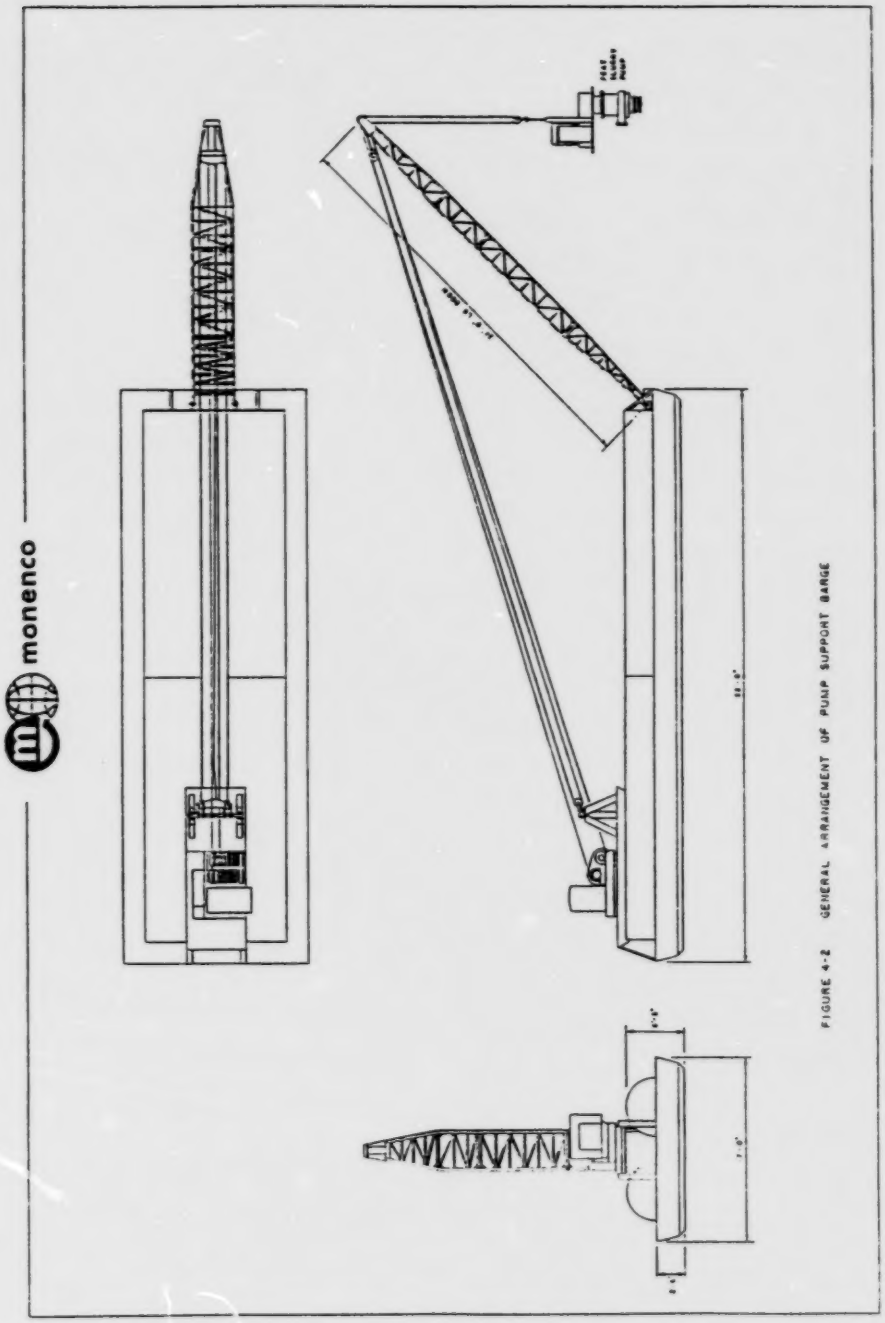


FIGURE 4-2 GENERAL ARRANGEMENT OF PUMP SUPPORT BARGE

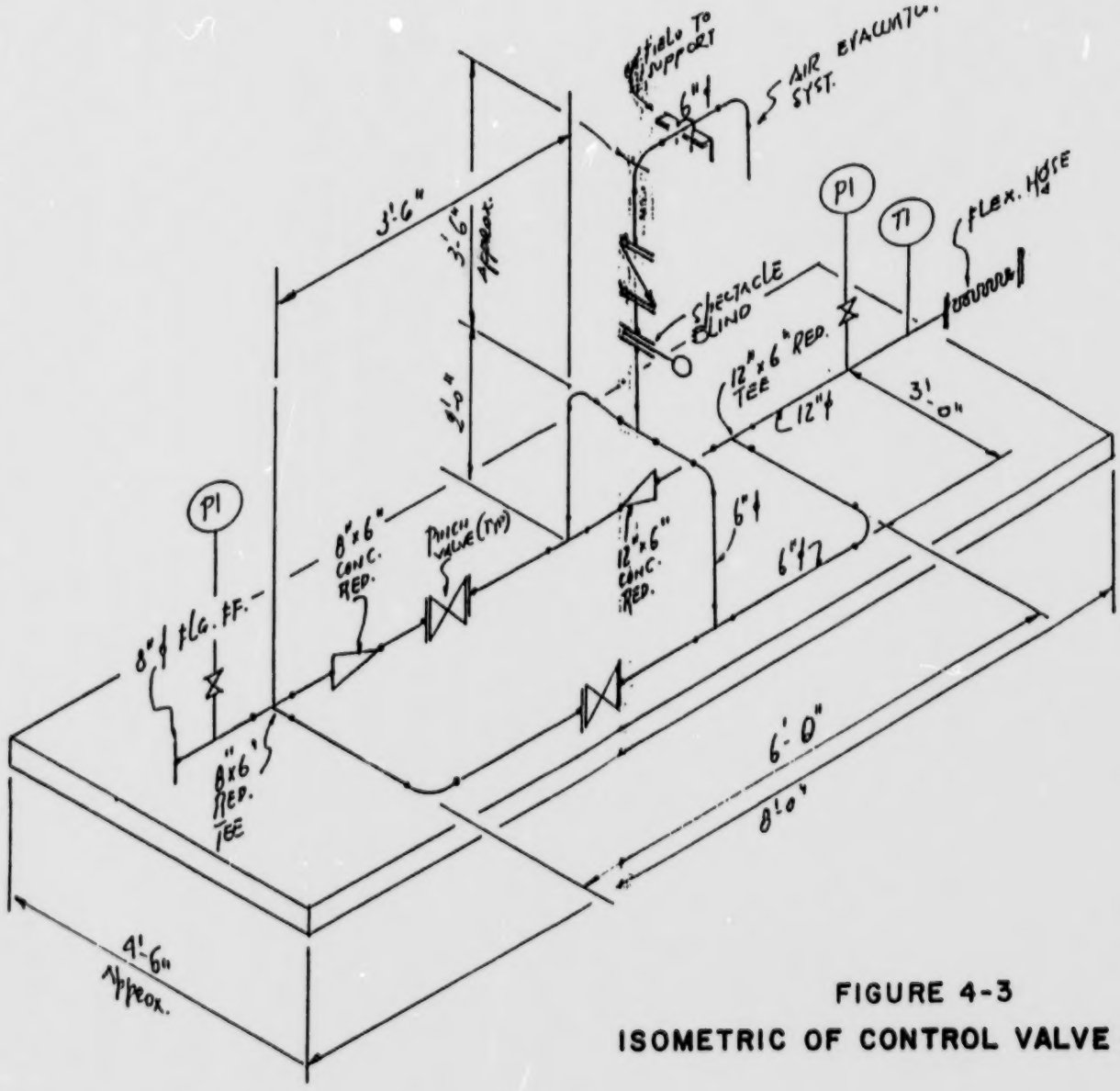


FIGURE 4-3

ISOMETRIC OF CONTROL VALVE STATION

Section 5

PEAT SLURRY PUMPING TRIALS

TEST OBJECTIVES

The main objectives of the peat slurry pumping test were:

- to see if the Monenco-designed peat slurry pump/macerator would actually work in an industrial-scale peat slurry pumping application;
- to quantify the performance of the peat slurry pump and the pipeline system under varying conditions, e.g., changes in the main pumping parameters, changes in the main physical and chemical properties of the in-situ peat and under changing rheological conditions of the peat and water mixture (the peat slurry);
- to determine the effectiveness of the hydromonitors as a mining (and a partial processing) tool, and to compare their performance to the previous USSR hydromonitor experience; and
- to carry out additional studies on the maceration, settability and dewaterability of peat slurries as prepared by the hydromonitor - peat slurry pump/macerator system.

TEST PROCEDURE

Mining

Peat was extracted from the area of the deposit which detailed analysis had shown to contain the lowest ash content peat. It was located between cross-lines 65E to 95E (about 100 ft) and 55 ft North and 70 ft South of the base-line. Steel conduit pipe (20 ft (6 m) lengths) with depth interval markings was used for depth control (to locate the lowest ash peat layer) during the mining test operations.

A peat slurry was produced by directing the powerful jets of water at the peat bed. The water jets were used to cut through the peat layers and to initially establish a sump which was part of the working pit later developed. The sump was approximately 20 ft by 26 ft (6 m by 8 m) and about 13 to 14 ft (4 to 4.3 m) deep, although about 2 ft (0.6 m) of peat commonly settled in the sump. The sump was located, taking into consideration depth of the peat deposit and slope of the underlying peat/mineral layer contact.

Once the sump was established, a trench was developed to the east as a continuation of the sump. It had a varying width of 20 to 25 ft (6.1 to 7.6 m) at the surface and was about 7 to 10 ft (2.1 to 3 m) wide at the bottom, and was about 100 ft (30 m) long. The bottom of the trench was sloped to allow gravity flow of peat slurry toward the sump where the peat slurry pump was located. The bottom elevation difference over the 100 ft (30 m) of trench length was about 2 ft (0.6 m).

The next stage of mining and peat slurry preparation involved excavation of the main mining pit, using the hydromonitors. In fact, excavation of the mining pit was carried out in three steps, (a) removal by selective mining of the top, higher ash content layer (about 6.5 ft (2 m) thick), and pumping of this material to the slurry reservoir, and similarly, (b) removal of a second, medium ash content layer (about 2.5 ft (0.8 m) thick), followed by (c) excavation of the deeper, lower ash content layer (about 2.5 ft (0.8 m) thick).

Use of the hydromonitors required careful co-ordination of the water supply pumping activities. The main water supply pump was monitored closely regarding water level to avoid pick-up of any silt or sediment which could damage the high pressure pumps, due to the close tolerances of the pumps' mechanical parts. It was also necessary to provide 200 to 300 lbs of ballast on the hydromonitor bases (depending on operating pressures) to prevent them from overturning.

Pumping

The support barge was used to position the peat slurry pump at the desired location over the sump. Peat slurry prepared by the hydromonitors entered the sump and was pumped by peat slurry pump through the pipeline to the slurry reservoir.

During removal of the top peat layers (higher ash content) the peat slurry pump was operated at a nominal 800 rpm (measured 792 rpm) with one inch clearance between the impeller and wear plate. The initial pump operating parameters were selected for the following reasons:

- considered to be most suitable for removal of the high ash content top layer with considerable surface vegetation;
- 800 rpm represented an expected average operating pump speed, (e.g., between 600 and 1000 rpm);
- one inch was the maximum designed pump clearance and would provide lowest pump capacity (based on shop test on water), best for start-up conditions (e.g., pipeline, system, power supply, etc.); and
- one inch clearance was expected to provide the best possible entrained air handling characteristics, reported to be a problem with the previous USSR model peat slurry pumps - they had an elaborate air evacuation system.

During removal of the top layer of highest ash content peat (up to 6.6 ft or 2 m deep), the following aspects of the pumping/pipeline system were noted:

- the effect of pump submergence;
- stability of the 12 inch (0.3 m) PVC pipeline in operation;
- characteristics of the control valve skid for regulation of slurry flow and detection of potential air entrainment problems;
- operational characteristics and overall reliability of the system including water supply, high pressure pumps, hydromonitors, peat slurry pump, pipeline system, hoist drive motors and power supply;
- performance of the field laboratory; and
- performance of operating and support personnel.

Following removal of the top peat layer, the pump was placed on the bog surface and the stump deflector and macerator assembly were removed by

personnel from the pump manufacturer for inspection of the pump and insertion of an additional wear plate to decrease the clearance to 0.5 inches.

The Monenco-designed pump (constructed by Allis-Chalmers) experienced no air entrainment problems and generally performed well during removal of the surface layer peat. Upon encountering the deeper, better quality peat it was decided to operate the pump at 800 rpm and 0.50 inch clearance, to attempt to achieve a higher pump capacity for further, more detailed pump and pipeline performance testing. During pump operation at 800 rpm (823 rpm measured) and 0.50 inches clearance, tests were conducted with and without the stump deflector. Higher pump capacity could have been achieved at 1000 rpm, but this test was not included due to limited water supply and project schedule/budget.

MINING AND SLURRY PREPARATION

Slurry Preparation

A fuel peat slurry prepared by hydromonitors results in a peat-water suspension containing an average of 92 to 97% water and 3 to 8% solids (on a wet weight basis). The desired degree of humification for fuel production should not be less than H4 to H5 on the von Post scale, equivalent to a degree of decomposition of 15% or more, as determined by the laboratory centrifugal method.

The process of maceration in the mining pit includes the break-up of the natural layered structure of the peat by the high pressure water jets. This process is very important and merits special attention for two reasons, (a) to maintain a smooth mining operation and, (b) to produce a good quality feedstock. Maceration also reduces the viscosity of the peat slurry. Viscosity is a major parameter of slurry flow because the higher the viscosity of the peat slurry, the lower its fluidity. A lower viscosity results in lower friction losses and, consequently, requires less energy to overcome resistance in the pipeline. In the case of wet peat mining using hydromonitors, the pressure of the water jets play an important role in the maceration process. Soviet experience with peat slurry preparation using high pressure water jets showed that about 50% of the maceration occurs during mining, 44% in the pump/macerator and 6% in the slurry pipeline.

Water Pressure/Hydromonitor Range

USSR experience showed that the distance from the high pressure water pump station to the hydromonitor should not be greater than 500 ft (152 m) to keep pressure losses within an acceptable level. The test site equipment for the water supply system was laid out to minimize pumping distances and elevation differences and avoid undue pressure losses. The distance between the main water supply pump and the high pressure water pump was about 100 ft (30 m). The distances between the high pressure pumps and the hydromonitors varied about 200 to 270 ft (61 to 82 m) during the mining operation.

Figure 5-1 shows the Stang model of hydromonitor (without hydraulic controls) manufactured in the U.S., and used in the test. The other hydromonitor shown in the USSR model GM-2. Common operating pressures for the model GM-2 hydromonitors were between 170 and 210 psi (1.2 and 1.4 mPa) using 1 to 2 inch (0.025 to 0.050 m) diameter nozzles with flow rates ranging 400 to 1300 USGPM (1515 to 4920 l/min).

Previous USSR experience with the use of hydromonitors on peat indicated an operating range of 33 to 59 ft (10-18 m) depending on the peat and peatland characteristics (peat type, degree of decomposition, stump content) and on the capacity of the peat slurry pump/macerator used to extract the peat slurry. Stang indicated a minimum of 50 ft (15 m) range for the peat application, based on their experience with other materials. Stang supplied three different sizes of nozzles (1.25, 1.5 and 1.75 inches (0.032, 0.038 and 0.044 m) diameter nozzle openings) to assist in regulation of the effective distance and nozzle pressures of the water jets.

An interesting feature of the Stang hydromonitor is the pipe configuration to control the momentum of the water prior to discharge through the nozzle. This contrasts with the previous USSR model hydromonitor (without the curved pipe) which experienced considerable difficulties in keeping the unit erect during operation, requiring laborious anchoring procedures. As well, the Stang hydromonitor was skid-mounted for ease of movement on the bog surface, and had safety stops to prevent the hydromonitor from being rotated at too severe an angle to the vertical axis. The Stang hydromonitor was available with remote control features, although not used for the test.

Water Quantity

The optimal solids content achieved using the "hydropeat" wet peat mining system in the USSR was defined as the solids content which provided the maximum system capacity in terms of peat output over a given time period. To determine the amount of water addition, factors such as the in situ moisture content of the peat, pump capacity and the required peat slurry solids concentration were considered. The water addition requirement was determined from the following equation:

$$Qw = \frac{Qsl \times W}{(1+W) \times a}$$

where Qw = the water supply pump capacity (USGPM);

Qsl = the peat slurry pump capacity (USGPM);

W = the water addition coefficient (this parameter was described in detail in the 1985 NRC report by Monenco "Development of Design Parameters for Peat Slurry Pumping and Pipeline Transport" pp. 4-16 to 4-19) where:

$$W = \frac{Cr-Csl}{Csl}$$

and Cr = the solids content of the in-situ peat deposit (in %);

Csl = the solids content of the peat slurry (in %); and

a = water losses to the bottom and sides of the mining pit and left in the pit after mining (% usually a=5%).

Instrumentation and Monitoring

Water for peat slurry preparation was provided by the main low pressure pump on the water reservoir which supplied the hydromonitors via two high pressure (booster) pumps. The maximum capacity of the low pressure pump was 2000 gpm (7570 l/min), although the level of delivery maintained for the duration of the testing program was between 1300 and 1700 gpm (4920 and 6440 l/min).

Discharge pressure and flow was monitored for both high pressure pumps. These were varied regularly during the sump preparation and testing stages. Both

systems had built-in gages which gave readings in pounds per square inch (psi) and litres per second. The discharge pressure of the water from the hydromonitor nozzle was also recorded during both the preparation and testing stages.

Table 5-1 presents all the essential data regarding the hydromonitor water supply system. The time recorded is the pump operating time, so the total water flow given is that which occurred only while the pump was running. All pressure readings were converted to feet of water (1 psi = 2.31 ft) and all flows to U.S. gallons per minute.

Pressure drops (feet per 100 feet) were calculated for each hydromonitor line. Greatest pressure drops occurred when the pump discharge pressure was highest. In general, high pressure pump no. 1 operated at the highest recorded flows and discharge pressures. This, and the difference in nozzle diameter, accounts for the difference between the two pipeline pressure drops. Hydromonitor nozzles were changed a number of times during the pumping trials.

Test Results - Hydromonitor Performance

Previous USSR information showed that for a partially drained peatland (average bog moisture content for ½ m surface layer of 90-92%), the following relationship between peat depth and minimum distance of hydromonitor from edge of mining pit should be maintained during excavation for safety reasons (for manually-operated hydromonitor):

Mining Depth (m)	Distance from Edge (m)
1.5	2.7
2.0	2.1
2.5	1.5
3.0	1.0
greater than 3.5	0.5

The above geometry was required when using hydromonitors with an effective range of maximum 15-20 m, to obtain the desired excavation depth. The Stang model hydromonitor used in the demonstration test had an effective range of

30 m. The maximum depth of excavation at the test site was 4.5 m and it is expected there is no real limitation on depth of excavation, except that imposed by site-specific mining criteria, such as area and depth of mining pit and slope stability of the peat deposit.

Performance data on the USSR model GM-2 hydromonitor is presented in Figure 5-2 and is compared with data obtained during the test on the Stang equipment. For a 1-3/4 inch (0.044 m) nozzle using the Stang equipment, the nozzle pressures recorded during testing were slightly higher than those recorded for a similarly sized nozzle mounted on the GM-2. Higher nozzle pressures and greater effective mining ranges of the water jets were attained using the Stang hydromonitors and booster pumps selected for the test as compared with the ranges given for the USSR model.

During the mining and pumping demonstration tests (for both high and low ash peat slurries), solids concentrations of between 1 and 10% (dry weight basis) were obtained. The water addition rate through the hydromonitors for slurry preparation was calculated based on the desired solids concentration, the moisture content of the layer being mined (80 to 86%) and desired slurry pump capacities. Following each test, the slurry pumping rates were compared to the amount of water added and the solids concentrations achieved. Based on the daily pumping results, adjustments to the water addition amount were made for the next set of tests to achieve a range of values of test results.

Figure 5-3 shows the calculated amount of water addition needed to prepare a slurry concentration of 3.7%, at different peat slurry pumping capacities. Pro-rated data gathered during the test for peat slurries with or near 3.7% solids concentration are also shown (following the overall water balance analysis). The figure shows the test data points do not stray far from the predicted values.

PEAT SLURRY PUMPING AND PIPELINE PERFORMANCE

Instrumentation and Monitoring

The peat slurry pumping system including the 12 inch (0.3 m) pipeline was monitored for those parameters required for a detailed pump performance evaluation (see Figure 5-4).

- o pump operating time;
- o flowrate;
- o pressure drop (at four locations);
- o temperature;
- o elevation;
- o pump power demand and consumption; and
- o shaft rotational speed.

The variability of the physical characteristics of the peat slurry made selection of a suitable flow measurement device difficult. The solids content of the peat slurry ranged from 1% up to 10% (Appendix B). Vegetation growing on the peatland was slurried together with the peat and pumped through the pipeline. Grasses, woody remnants, lumps of peat, etc. constituted part of the initial slurry. Therefore, it was decided not to employ a rotating type flowmeter, in favor of either a magnetic or an ultrasonic doppler flowmeter.

A magnetic probe type meter pre-calibrated for a 12 inch pipe and with remote digital read-out, was selected with a portable ultrasonic meter as a back-up. The magnetic probe did not operate as well as expected. The probe, which extended approximately two inches (0.05 m) into the pipeline, became continually coated with material entrained in the slurries pumped early in the trials, and probably suffered some damage as a result. The portable ultrasonic flowmeter, which did not require any contact with the slurry, was used for all the tests and performed well. This type of flowmeter has been finding an increasing level of application in the pulp and paper industry. Efforts were also made to estimate flow from an empirical formula based on some simple measurements made at the pipe outlet. However, this method gave somewhat

erratic results and, therefore, all slurry flow data reported for the test period (23.08.85 to 26.08.85) were based entirely on the ultrasonic meter, which recorded in feet per second.

To measure pressure in the pipeline, it was necessary to employ gages which would be completely isolated from the peat slurry. This was to prevent clogging of the pressure sensing tube inside the gauge. Mineral oil filled gage protectors were used, which allowed slurry pressure transmission for subsequent recording. Four gages, which gave readings in pounds per square inch (psi) were employed at six positions during the tests. Prior to their installation, all pressure gages were tested on a local water supply outlet.

Temperature was measured using a standard temperature gage inserted in the pipeline. Readings were in degrees Celcius.

In order to calculate the efficiency of the pump, it was necessary to measure power consumption. A kilowatt demand and kilowatt-hour totalizing meter was installed at the power generator set. The determination of pump efficiency included the power demand to operate the complete pumping, macerating and external propeller units and, as well, the energy losses in the power transmission system (V-belt drive from motor to pump shaft) were not evaluated and therefore efficiency was not established on an absolute basis: the values of efficiency shown should be treated qualitatively, simply to notice on the pump performance curves where the highest pump efficiency occurs.

To measure pump speed, a magnetic sensor which counted the rotations of a 60 tooth gear mounted on the pump shaft was employed. Speed in rpm was monitored continuously from a remote digital read-out.

Data on monitoring and analytical equipment used at test site are shown in Appendix C.

Sampling and Analysis

During each test run, a minimum of three 0.066 gal (250 ml) samples were taken from the pipeline discharge. Small portions of selected samples were used for moisture, ash and viscosity determinations in the site laboratory, (Appendix B) with the remainder being shipped to ORF laboratories for subsequent settlability, dewaterability and particle size classification tests. Moisture, ash and viscosity tests were also repeated at the ORF laboratory. Sump samples were taken periodically, mainly for particle size distribution. All samples were kept in a cool location in the site laboratory prior to removal to the ORF laboratory, where they were placed in cold storage.

Moisture content was determined using a 'fast method' similar to that employed in the U.S.S.R. Slurry samples were dried by a heat lamp and a moisture balance was used. Ash content was measured by heating dried peat in a furnace for 50 minutes at 1562°F (850°C). Slurry viscosities were determined using a Thomas-Stormer viscometer.

These rapid moisture and ash content determination methods were intended to provide an indication of peat quality as it was being mined.

Test Results

Top Layer Peat (pump speed - nominal 800 rpm, one inch clearance)

Appendix 'D', "Pump Test Data Sheets" contains the individual field test data sheets from the pumping trials. Appendix 'E', "Calculation Sheets - Pumping and Mining Parameters" contains two tables of performance calculations, based on the data in Appendix 'D', and laboratory analytical results on the peat and peat slurry samples, for the peat slurry pump and pipeline system.

Although 17 tests were carried out during the period August 15, 1985 to August 22, 1985, only 11 were selected for analysis because of incomplete data due to instrumentation malfunctions during this "run-in" period. During the 11 test "runs", approximately 2200 cu.yd. (1690 m^3) of in-situ peat were extracted.

Arrangement of the peat slurry pump in the operating position is shown at Figure 5-5.

Table 5-2 includes the test results from this initial pumping period. It shows that the pump flow rate varied from 1040 to 1760 USGPM (236 to 400 m^3/hr) and was generally lower than the results, from the previous water performance tests at the pump manufacturer's plant. However, the slurry solids concentration was much higher than expected (up to 10% solids by weight, due to the high ash content in the surface layer peat) and the peat slurry flow velocity was about 25% to 30% lower than during the water test. As well, the B.h.p. requirement and total head developed was lower than expected, compared to the previous shop performance tests on water as performed at the manufacturers plant (see Figure 5-6), which showed that a head of 44.5 ft (13.6 m) could be developed at 2100 USGPM (7950 l/min) flow rate, at the maximum pump efficiency point.

The top, high ash content, layer of peat was not considered representative of typical fuel peat. As well, it was not possible to vary the control pinch valve setting from the full open position (to obtain data at various flow rates) due to the high consistency of the slurry and the risk of damage to the pipeline system. For these reasons, performance curves for the pump and pipeline system were not prepared, however, a considerable amount of test data was collected which is available for use in the future, if necessary, to give an indication of its performance on high solids concentration slurry.

After extraction of the top layer of peat, the slurry pump was recovered from the pit and dismantled for inspection by the manufacturer's pumping specialists. Generally the mechanical condition of the pump was good, and no damage, wear or corrosion was noted, although the total operating time period was of short duration (approximately 14 hours). The water lubrication system for the main shaft bearings appeared to have performed well. The pump clearance between the impeller and wear plate was reduced to 0.5 inches.

Bottom Layer Peat (pump speed - nominal 800 rpm, 0.50" clearance)

Thirteen, fully monitored, performance tests were carried out on the lower ash content peat at various pump capacities (three per test) over the period August 23, 1985 to August 26, 1985 inclusive during a total monitored time period of 5.6 hours or about 26 minutes per test. The tests were generally of short duration because of the limited water supply due to an unseasonable drought period, and since it was desired to perform pumping tests over a range of conditions. Approximately 600,000 U.S. gallons of slurry and 500,000 U.S. gallons of water were pumped (Appendix E).

Ten tests of the thirteen were with the stump deflector on the pump and three tests were performed without the stump deflector.

Table 5-3 and Figures 5-7 and 5-8 show the pump performance data for different peat slurry solids concentrations and also the comparison of performance with water. Figures 5-7 and 5-8 are based on actual test data and estimated performance data as calculated in Appendix 'F'. The original test data can be readily grouped according to solids concentration levels of 2.6%, 4.5% and 5.9%, by weight, to show the various relationships between changes in slurry solids concentration and main pumping parameters such as flow rate and dynamic head. Figure 5-7 shows the head loss versus pump capacity for different solids concentrations; only a 3% difference in head loss at a given pump capacity was experienced over the range of solids concentration from 2.6% to 5.9% (by weight).

Figure 5-8 compares pump performance on water and 3.7% peat slurry. Due to experimental conditions at the site (water supply, fluctuations in peat in-situ moisture content, etc.), it was not possible to obtain sets of data for various specific solids concentration levels. Therefore, the data was averaged at 3.7% solids concentration for presentation in this report. Figure 5-8 shows that the peat slurry curve was 15% lower than water over the range of pump flow rates tested. Brake horsepower and efficiency curves for water and peat generally showed that the energy requirement for peat slurry pumping was about 21% greater than water and that the best efficiency point was about 8% lower than the best efficiency point for water.

Table 5-3 shows the pump performance results on peat slurry of different solids concentrations from 1% up to 7.1% solids by weight. Although the pump efficiency ranged from 23.4% to 32.8%, curve fitting of the data shows that the estimated maximum pump efficiency of 28% occurs at 1800 USGPM (6813 1/min) at a head of 58 ft (17.7 m).

Table 5-4 shows pump performance results on water and peat at varying clearances between the impeller and wear plate, at an average 3.7% solids concentration. Maximum expected pump capacity on peat slurry (3.7% solids concentration) is 4000 USGPM (15140 1/min) at the maximum clearance of 0.03 inches and at 1000 rpm pump speed.

Figure 5-8 also shows the performance characteristic for the pump and the pipeline system when the static head is equal to 18.6 ft (5.7 m) for different positions of the control valve. This curve is based on calculations given in Appendix 'F'. Figure 5-9 illustrates pressure losses in the pump and pipeline system based on the test data from Test #9, Run #1 (see Appendix 'E').

Table 5-5 compares the pump and pipeline performance at different peat slurry pump clearances between impeller and wear plates, with peat slurry. Although it is not strictly correct to compare performance data at maximum pump efficiency (e.g. 0.5 inch clearance) to the average test data (e.g. at one inch clearance), this table is included to provide a preliminary indication of the effect on the major pumping parameters by varying the clearance from 0.5 inches to 1.0 inches. The pump was designed with a variable clearance between impeller and wear plate to combat expected air entrainment problems reported from the previous USSR experience. The variable clearance between impeller and wear plate was recommended by the manufacturer during the preliminary design review stage of the project, and proved to be effective in handling air entrainment, as no problems with air were encountered.

Table 5-5 also indicates that for the same peat slurry viscosity characteristic and about the same range of solids concentration, head losses in the pipeline were approximately the same. However, the peat slurry, at one inch clearance, was much higher in ash content than the peat pumped at 0.5 inch

clearance, although the higher ash content did not appear to affect the main peat slurry flow parameters.

Figure 5-10 and Table 5-4 compare pump performance with and without the stump deflector. For the same flow rate, a small improvement (2%) in pump efficiency was noted and a 3% lower B.h.p. was required when the stump deflector was removed. Previous performance tests on water, with and without the stump deflector, showed a 3.8% decrease of pump dynamic head without a stump deflector. The previous USSR data indicated a 5% change; our results were based on a limited number of tests.

A comparison was made between the Monenco design peat slurry pump and the USSR TDD-4A pump (see Figure 5-11 and Table 5-6). It should be noted in Figure 5-11 and Table 5-6 that the performance characteristic for the Monenco pump at 1000 rpm and 0.03 inch clearance was developed from a pro-rating of test data obtained on peat slurry at 823 rpm and 0.5 inch clearance, and water test data at 1000 rpm and 0.03 inch clearance (see Figure 5-12 and Appendix 'F'). It is expected that at 1000 rpm pump speed and 0.03" clearance, the efficiency of the Monenco pump would be slightly higher, with a higher flow rate and, consequently the meter horsepower significantly greater, at a given head, as compared to the TPD-4A.

The USSR TPD-4A pump has a larger impeller diameter but lower pump rpm, in comparison with the Monenco pump. The effect of a change in impeller diameter is similar to a change in pump speed; both result in a change in the speed of the slurry which leaves the impeller, and therefore the larger diameter impeller of the TPD-4A pump somewhat compensates for its low speed when compared with the Monenco pump. The USSR TPD-4A pump was designed for a maximum pump speed of 600 rpm.

The TPD-4A pump has a maximum efficiency of 48% at 3520 USGPM (800 m^3/hr). The estimated efficiency of the Monenco pump (at 0.03" clearance and 1000 rpm) is 53% at 4050 USGPM (920 m^3/hr).

Figures 5-13 and 5-14 show the relationship between pressure loss and peat slurry flow velocity in the pipeline for different solids concentrations of fuel quality peat slurry. Figure 5-13 is based on field test data for the peat slurry pump at 823 rpm, 0.5 inch (1.3 cm) clearance and in the 12 inch (300 mm) PVC pipeline. It shows that the higher solids concentration slurries experienced higher pressure losses than lower solids concentration slurries, for the same pump capacity. This information was also plotted for comparison against data available to Monenco from field tests on Swedish peat (Figure 5-14), for the same diameter (12 inch, 300 mm) of plastic pipeline.

The Monenco test results (pressure loss versus flow velocity) are very similar to the previous Swedish information. It is assumed that the differences between the Monenco and Swedish curves are due to the differences in peat characteristics and slurry temperature, although detailed information on the Swedish data (such as peat type, degree of decomposition, ash, viscosity of peat slurry, maceration, etc.) was not available.

Figure 5-15 shows the flow rate versus equivalent length of pipeline for a 823 rpm (0.5" clearance) and a 1000 rpm (0.03" clearance) peat slurry pump. This figure gives useful preliminary pumping and pipeline system design information, based on the test results for the pump capacities, pipeline and changes in pump parameters studied.

Figure 5-16 is taken from the Monenco "Phase 1" report and was based on previous USSR data and shows the relationship between peat slurry viscosity and solids concentration for various peat types and peat quality characteristics. The USSR information was developed over a long time period in industrial peat slurry pumping applications. It also shows data from laboratory investigations carried out in previous Monenco Phase 1 work on slurries prepared from North American peat samples. Data from the field test has been added to the figure which shows that for the peat type encountered at Vestal, New York, the optimum peat slurry solids concentration using the "hydropeat" method should be about 6.7% (by weight).

Table 5-1

WATER USAGE BY HYDROMONITORS

DATE	TEST #	NOM #	TIME (MIN)	FLOW 1 (GPM)	P 1 (PSI)	FLOW 2 (GPM)	P 2 (PSI)	NOM P1 (PSI)	NOM NOZ 1 SIZE (INS)	PRES DROP 1 (FT/100 FT)	NOM P2 (PSI)	NOM NOZ 2 SIZE (INS)	PRES DROP 2 (FT/100 FT)	TOTAL FLOW (U S GAL)	TOTAL FLOW RATE (GPM)
15.08.85	TRI	1	77	951	160	666	150	155	1.75	4.9	145	1.5	5.9	124486	1617
16.08.85	TRI	1	24	793	160	824	135	155	1.5	4.9	110	1.75	19.9	38801	1617
17.08.85	TRI	1	164	594	105	745	107	96	1.5	8.8	105	1.75	2.3	219649	1339
19.08.85	TRI	1	21	650	160	380	30	155	1.75	4.9	10	1.5	14.1	21635	1030
		2	35	650	160	380	30	155	1.75	4.9	10	1.5	14.1	36059	1030
		3	36	1094	210	444	40	182	1.75	27.4	35	1.5	5.9	55348	1537
	TRI	4	127	1094	210	444	40	182	1.75	27.4	35	1.5	5.9	195256	1537
		5	17												
20.08.85	TRI	1	110	1094	210	0	0	185	1.75	24.5	0	1.75	0.0	120302	1094
	TRI	2	32	0	0	856	145	0	1.75	0.0	135	1.75	11.7	27389	856
	TRI	3	59	1062	200	0	0	180	1.75	19.6	0	1.75	0.0	62655	1062
21.08.85	TRI	1	75	1030	190	396	23	165	1.75	24.5	20	1.75	3.5	106980	1427
		2	156	1078	200	888	160	166	1.75	33.3	145	1.75	17.6	306602	1965
22.08.85	TRI	CLR	05												
		1	20	856	130	333	18	112	1.75	17.6	15	1.75	3.5	23775	1189
		2	20	872	120	428	32	110	1.75	17.6	30	1.75	2.3	25994	1300
		3	21	872	120	428	32	110	1.75	17.6	30	1.75	2.3	27294	1300
		4	12	793	100	0	0	95	1.75	4.9	0	1.75	0.0	9510	793
23.08.85	TRI	CLR	15	0	0	729	120	0	1.75	0.0	115	1.75	5.9	10937	729
	1	1	14	793	110	444	30	96	1.75	13.7	30	1.75	0.0	17308	1236
		2	21	793	110	793	150	96	1.75	13.7	120	1.75	35.2	33296	1586
		3	13	793	110	793	150	96	1.75	13.7	120	1.75	35.2	20612	1586
	2	1	11	793	110	793	150	96	1.75	13.7	120	1.75	35.2	17441	1586
		2	10	793	100	872	150	92	1.75	7.8	135	1.75	17.6	16648	1665
		3	15	793	100	872	150	92	1.75	7.8	135	1.75	17.6	24971	1665
24.08.85	TRI	CLR	15	0	0	713	110	0	1.75	0.0	100	1.75	11.7	10699	713
	3	1	10	682	70	682	100	60	1.75	9.8	95	1.75	5.9	13631	1363
		2	7	682	70	682	100	60	1.75	9.8	95	1.75	5.9	9542	1363
		3	10	682	70	682	100	60	1.75	9.8	95	1.75	5.9	13636	1364
	4	1	9	666	70	761	120	65	1.75	4.9	115	1.75	5.9	12839	1427
		2	6	666	70	840	150	65	1.75	4.9	135	1.75	17.6	9036	1506
		3	4	666	70	840	150	65	1.75	4.9	135	1.75	17.6	6024	1506
26.08.85	5	1	12	999	170	571	110	150	1.75	19.6	110	1.5	5.9	18830	1569
		2	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10987	1570

Table 5-1 cont'd

	3	10	999	170	571	115	150	1.75	19.6	110	1.5	5.9	15696	1570
6	1	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10987	1570
	2	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10987	1570
	3	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10987	1570
7	1	6	999	170	571	115	150	1.75	19.6	110	1.5	5.9	9418	1570
	2	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10987	1570
	3	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10987	1570
8	1	8	999	170	571	115	150	1.75	19.6	110	1.5	5.9	12557	1570
	2	6	999	170	571	115	150	1.75	19.6	110	1.5	5.9	9418	1570
	3	9	999	170	571	115	150	1.75	19.6	110	1.5	5.9	14130	1570
9	1	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10990	1570
	2	6	999	170	571	115	150	1.75	19.6	110	1.5	5.9	9420	1570
	3	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10990	1570
10	1	6	999	170	571	115	150	1.75	19.6	110	1.5	5.9	9420	1570
	2	6	999	170	571	115	150	1.75	19.6	110	1.5	5.9	9420	1570
	3	5	999	170	571	115	150	1.75	19.6	110	1.5	5.9	7850	1570
11	1	6	999	170	571	115	150	1.75	19.6	110	1.5	5.9	9420	1570
	2	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10990	1570
	3	6	999	170	571	115	150	1.75	19.6	110	1.5	5.9	9420	1570
12	1	7	999	170	571	115	150	1.75	19.6	110	1.5	5.9	10990	1570
	2	8	999	170	571	115	150	1.75	19.6	110	1.5	5.9	12560	1570
	3	3	999	170	571	115	150	1.75	19.6	110	1.5	5.9	4710	1570
13	1	3	999	170	571	115	150	1.75	19.6	110	1.5	5.9	4710	1570
	2	3	999	170	571	115	150	1.75	19.6	110	1.5	5.9	4710	1570
	3	4	999	170	571	115	150	1.75	19.6	110	1.5	5.9	6280	1570

TOTAL 1351 MINUTES 1271724 GALLONS

Table 5-2

PUMPING TEST RESULTS FOR PEAT SLURRY AND WATER
(792 rpm, 1 inch clearance, with stump deflector)

Parameter	Unit	Slurry Test Data		Water Test Data at Maximum Efficiency
		Range	Average	
Pump rpm	rpm	735-833	792	800
Pump Efficiency	%	11.3-23.5	-	32.8
Pump Flow Rate	USGPM	1040-1760	1360	2100
	m^3	236-400	309	477
Pump B.h.p.	HP	60-94	-	70
Static Head	feet	14.6	-	-
Total Head	feet	30.1-40.8	-	44.5
	m (water column)	9.2-12.4	-	13.6
Peat Slurry Solids Content (% dry weight)	%	1-10	46.7	-
Head Loss per 100 ft of Pipeline	ft	0.9-1.65	-	-

Table 5-3

PUMP PERFORMANCE TEST RESULTS FOR DIFFERENT SOLIDS CONCENTRATIONS
(823 rpm, 0.5 inch clearance, with stump deflector)

Parameter	Unit	Test Data	
		Range	Average
Pump rpm	rpm	785-833	823
Pump Efficiency	%	23.4-32.8	28.0
Pump Flow Rate	USGPM m^3	1620-2220 370-505	1800 400
Pump B.h.p.	HP	97.7-101.3	95.0
Static Head	feet	18.6	-
Total Head	feet m (water column)	45.1-62.6 13.7-19.1	58.0 17.7
Pump Capacity:			
a) In-situ Peat	cu yards/hr m^3/hr	-	146.8 112.2
b) 0% Moisture Content Peat	ton/hr tonne/hr	-	16.6 15.1
Peat Slurry Solids Content	%	1.0-7.1	3.7

Table 5-4

PEAT SLURRY PUMP PERFORMANCE RESULTS
ON WATER AND PEAT SLURRY AT DIFFERENT CLEARANCES

Test	Clearance Between Impeller & Wear Plate (inches)	At Maximum Pump Efficiency				
		Pump Rotational Speed (rpm)	Flow Rate (USGPM)	Total Head (feet)	Efficiency (%)	B.h.p.
Water	0.03	1000	4000	117	60.0	200
Peat Slurry (3.7% Solids Concentration)*	0.03	1000	4000	70	53.0	270
Water**	0.5	800	2080	63.5	30.5	78.5
Peat Slurry (3.7% Solids Content with Stump Deflector)	0.5	823	1800	58	28	95
Peat Slurry (3.7% Solids Content without Stump Deflector)	0.5	808	1800	58	28.5	92

* Pro-rated pump performance for 3.7% solids concentration from test data at 823 rpm, 0.5 inch clearance.

**Estimated pump performance on water pro-rated from test data at 800 rpm, 1.0 inch clearance.

Table 5-5

PEAT SLURRY PUMP AND PIPELINE SYSTEM PERFORMANCE
AND TEST RESULTS
(918 ft length of 12 inch dia. PVC pipeline)

Parameter	Unit	Test Data at Maximum Pump Efficiency (0.5" Pump Clearance with stump deflector)	Average Test Data (1" Pump Clearance with stump deflector)
Pump rpm	rpm	823	792
Maximum Pump Efficiency	%	28	16
Pump Flow Rate	USGPM	1800	1360
Pump B.h.p.	h.p.	95	77
Static Head	ft	18.6	14.6
Total Head	ft	58	35.5
Head Loss per 100 ft of Pipeline	ft	0.9-1.72	0.9-1.65
Peat Slurry Flow Velocity (in pipeline)	ft/sec	4.6-6.9	3.0-5.0
Peat Slurry Viscosity	cP	30-230	30-195
Peat Slurry Solids Content (% dry weight)	%	1-7.1	1-10
Peat Slurry Ash Content (% dry weight)	%	22.8-40.2	35-66
Peat Slurry Temperature	°C	17-19	18-24

Table 5-6

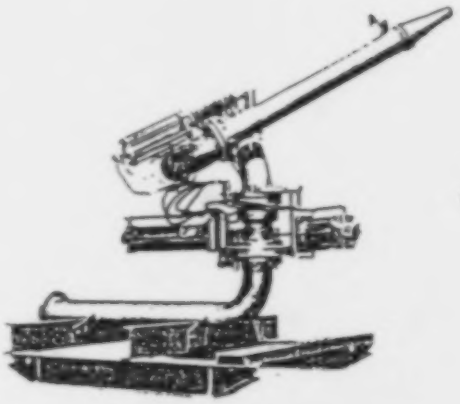
COMPARISON OF THE MONENCO AND USSR TPD-4A PEAT SLURRY PUMPS
(for peat slurry 3.7% solids concentration)

Item	Unit	Monenco Designed Pump		USSR Model TPD-4A (600 rpm)**
		Peat Slurry Test Data at 823 rpm 0.5" CLR	Pro-Rated Performance* for Peat Slurry at 1000 rpm, 0.03" CLR	
1. Total Head	feet m (water column)	52.5-59.1-65.6 16-18-20	52.5-59.1-65.6 16-18-20	52.5-59.1-65.6 16-18-20
2. Flow Rate	USGPM m^3/hr	2025-1735-1440 460-394-327	4300-4190-4050 977-952-920	3520-3080-2200 800-700-500
3. Impeller Diameter	inch cm	21 53.3	21 53.3	26.8 68.0
4. Power at the Drive Shaft	kw	74.5-72-69	181-180-179	74-73-72
5. Pump Efficiency	%	27-28-27	51-52-53	48-46-40
6. Electric Motor	hp kw rpm	150 112 1800	270 200 1800	121 90 580
7. Total Weight (without Motor)	lbs kg	4750 2155	4750 2155	4070 1845

* Estimated pump performance on peat slurry at 1000 rpm and 0.03" CLR pro-rated from test data at 823 rpm, 0.5" CLR.

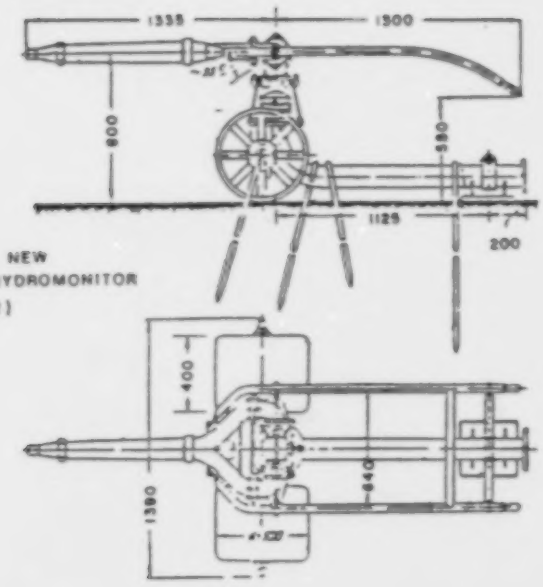
** Designed for maximum pump speed.

monenco



STANG WATER CANNON

(mining guns for hydraulic mining or slurrying, typically used in Florida pebble phosphate fields)



DETAILS OF NEW STANDARD HYDROMONITOR (USSR)

Source: (8,10)

FIGURE 5-1 HYDROMONITORS

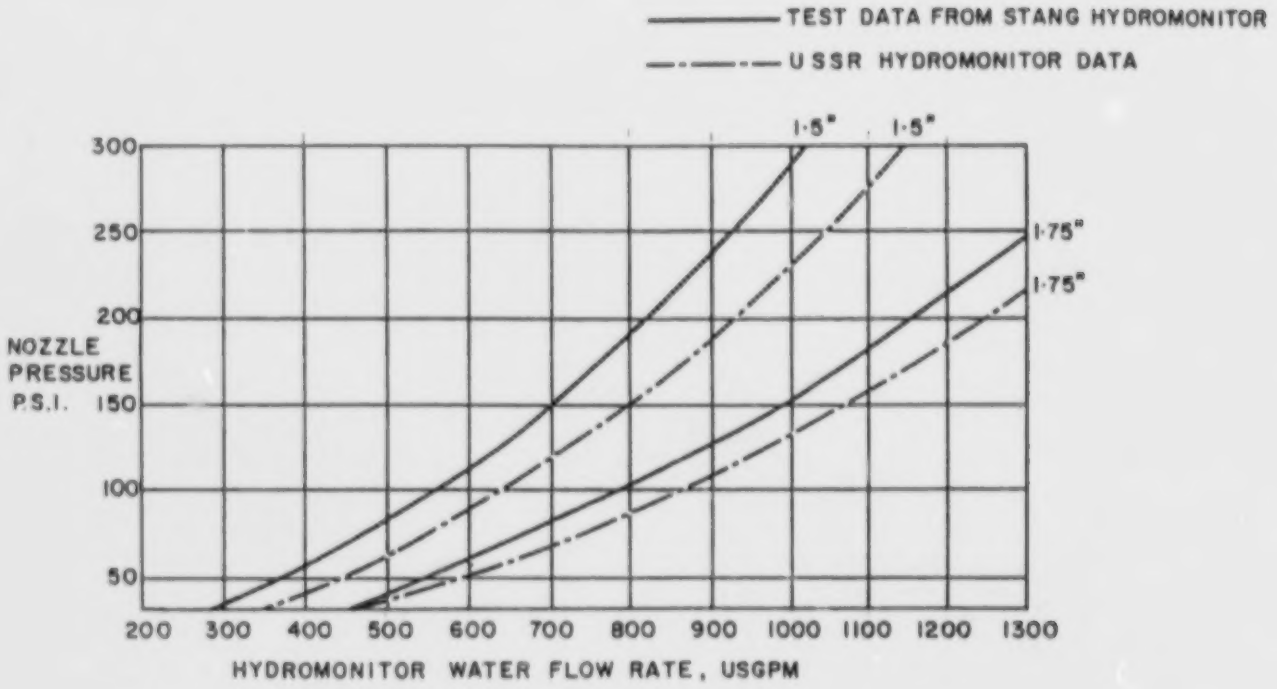


FIGURE 5-2 COMPARISON OF HYDROMONITOR FLOW RATES VERSUS NOZZLE PRESSURE FOR DIFFERENT DIAMETERS OF HYDROMONITOR NOZZLES (USSR VERSUS TEST DATA)

Source: (9)

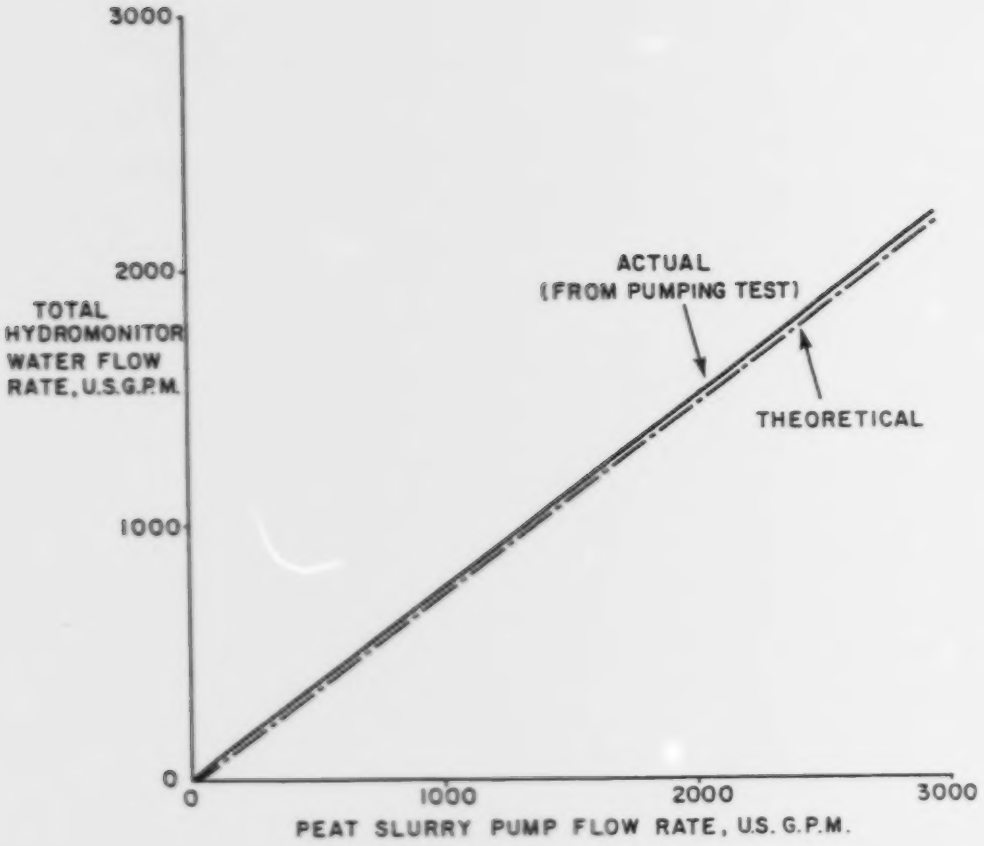


FIGURE 5-3 COMPARISON OF THEORETICAL AND ACTUAL WATER ADDITION REQUIREMENTS FOR 3·7% PEAT SLURRY SOLIDS CONCENTRATION

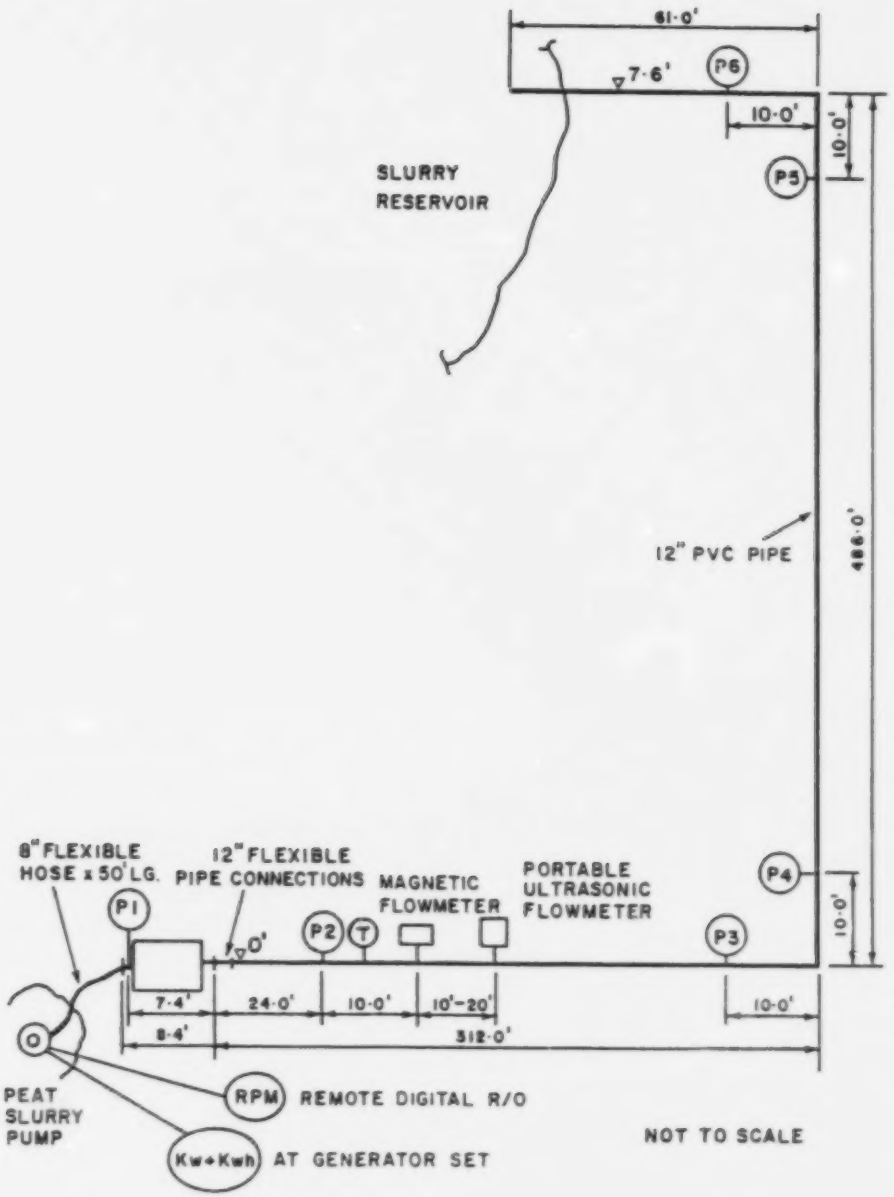


FIGURE 5-4 PIPELINE LAYOUT WITH INSTRUMENT LOCATIONS

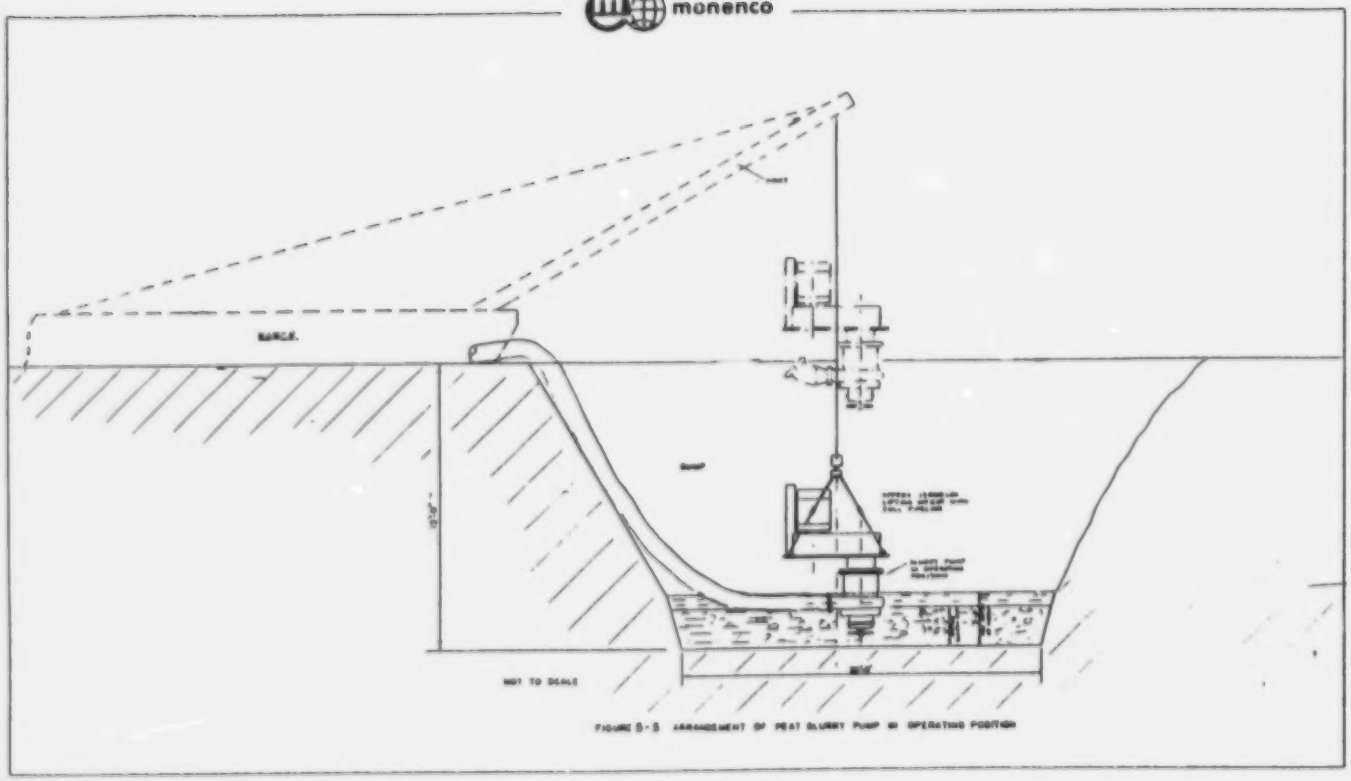


FIGURE 5-5 ARRANGEMENT OF PEAT SLURRY PUMP IN OPERATING POSITION

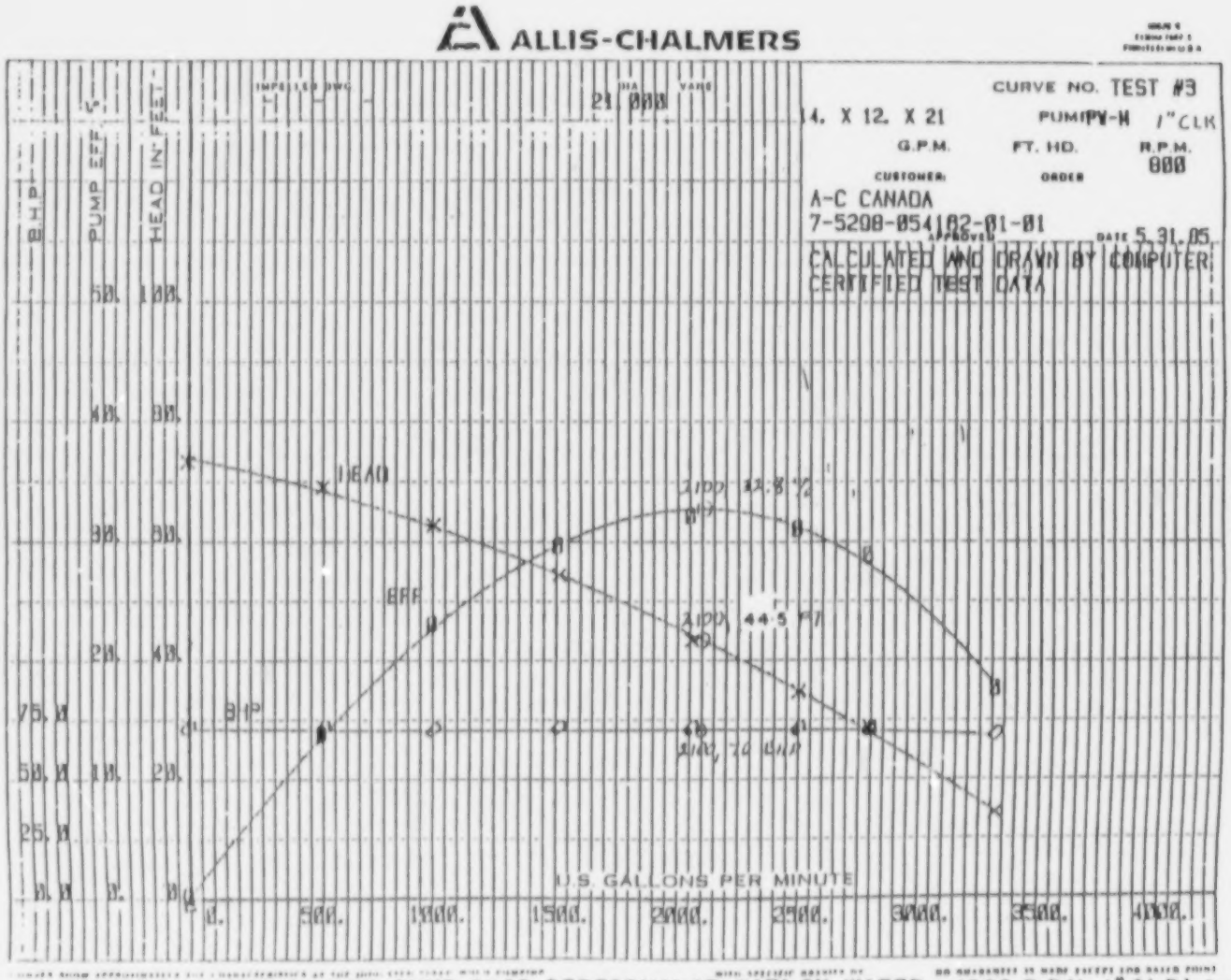


FIGURE 5-6 PEAT SLURRY PUMP SHOP PERFORMANCE DATA ON WATER (800 R.P.M. 1"CLK) Source (3)

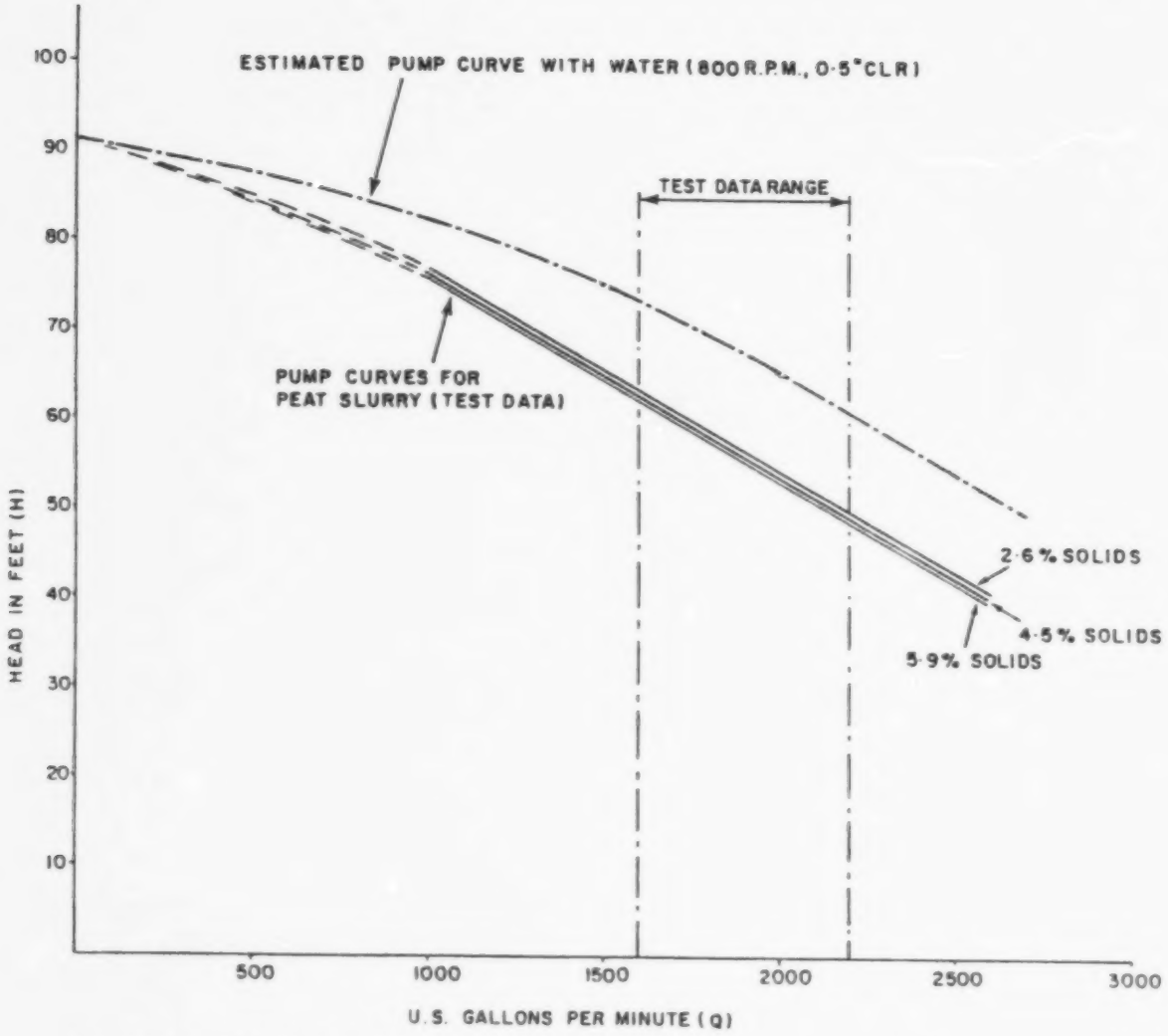


FIGURE 5-7 (823 R.P.M., 0·5" CLEARANCE) PEAT SLURRY PUMP PERFORMANCE CHARACTERISTIC FOR DIFFERENT PEAT SLURRY CONCENTRATIONS

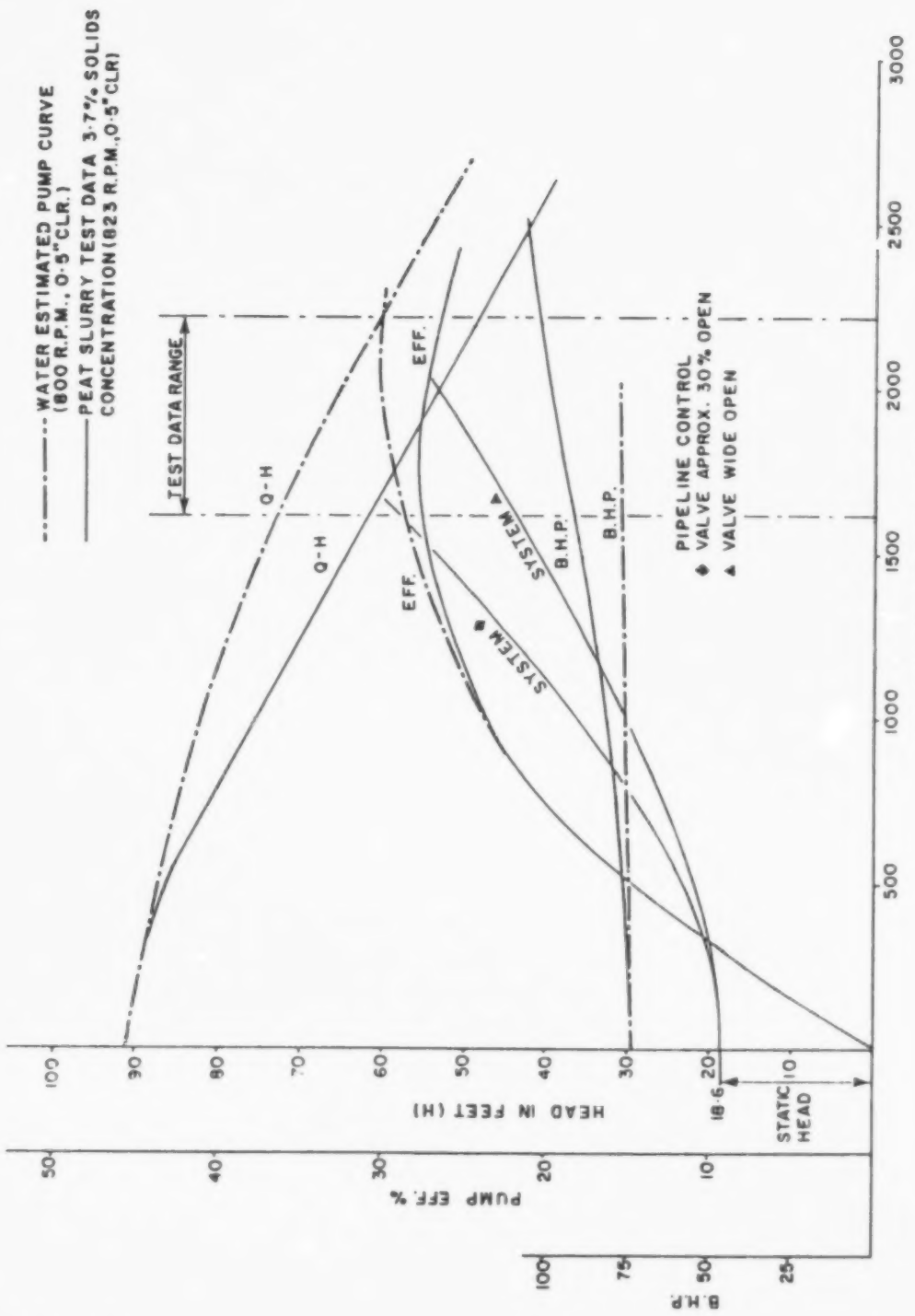


FIGURE 5-8 COMPARISON OF PEAT SLURRY PUMP PERFORMANCE ON WATER AND PEAT SLURRY

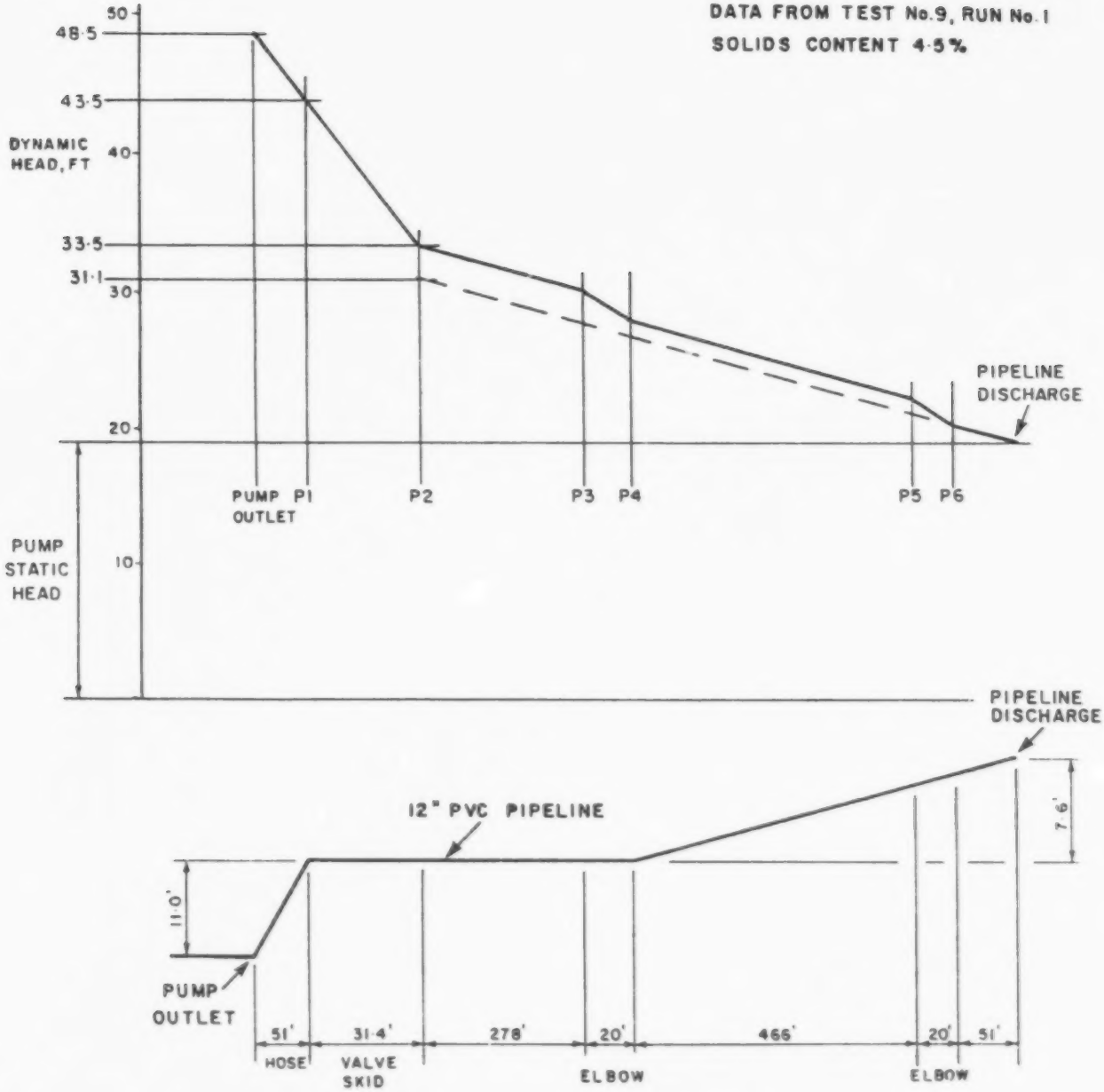


FIGURE 5-9 PIPELINE ELEVATION PROFILE AND PIPELINE PRESSURE DROP

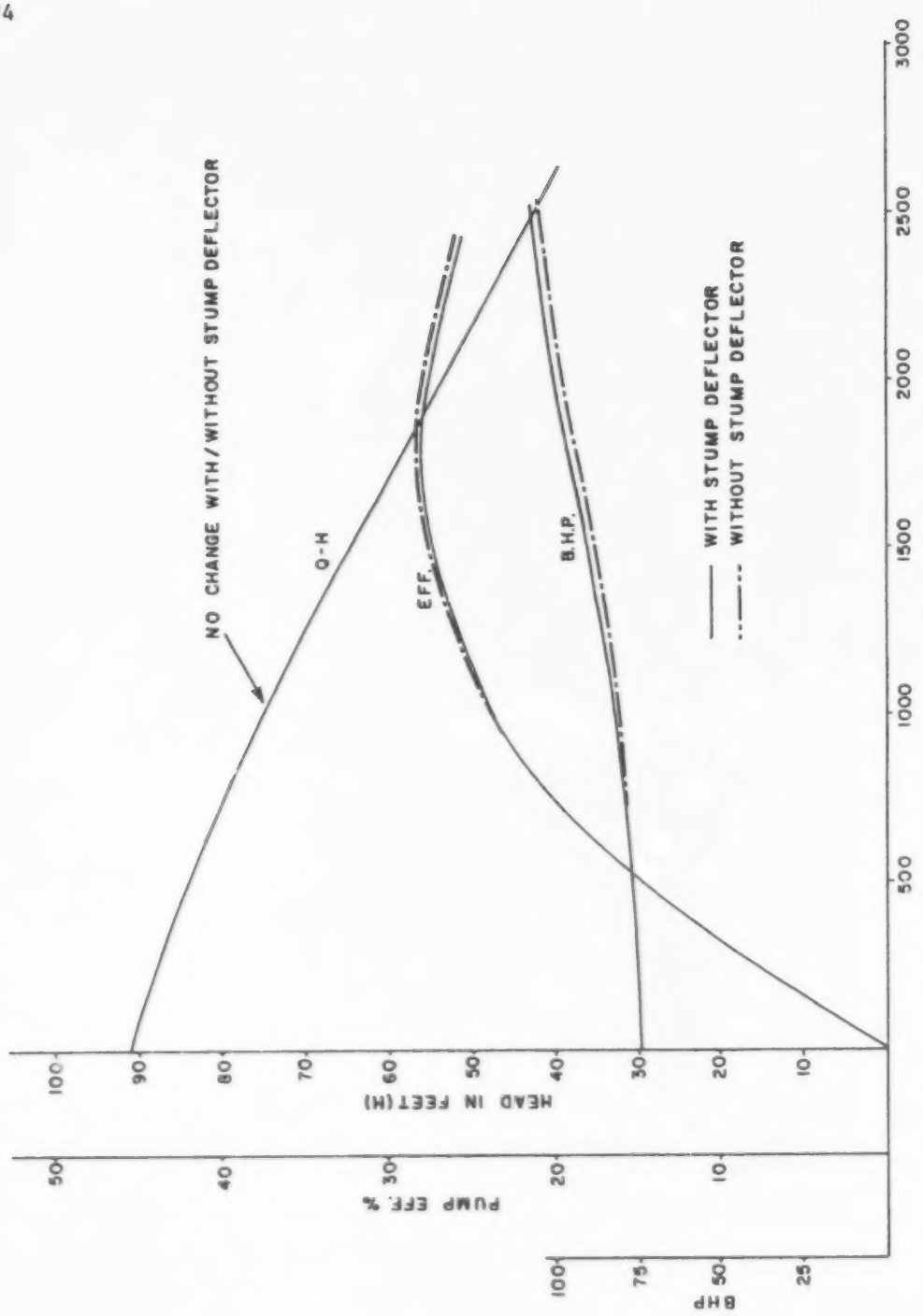


FIGURE 5-10 PUMP PERFORMANCE IN PEAT SLURRY WITH/WITHOUT STUMP DEFLECTOR (3·7% SLURRY CONCENTRATION, 823 R.P.M., 0·5" CLEARANCE)

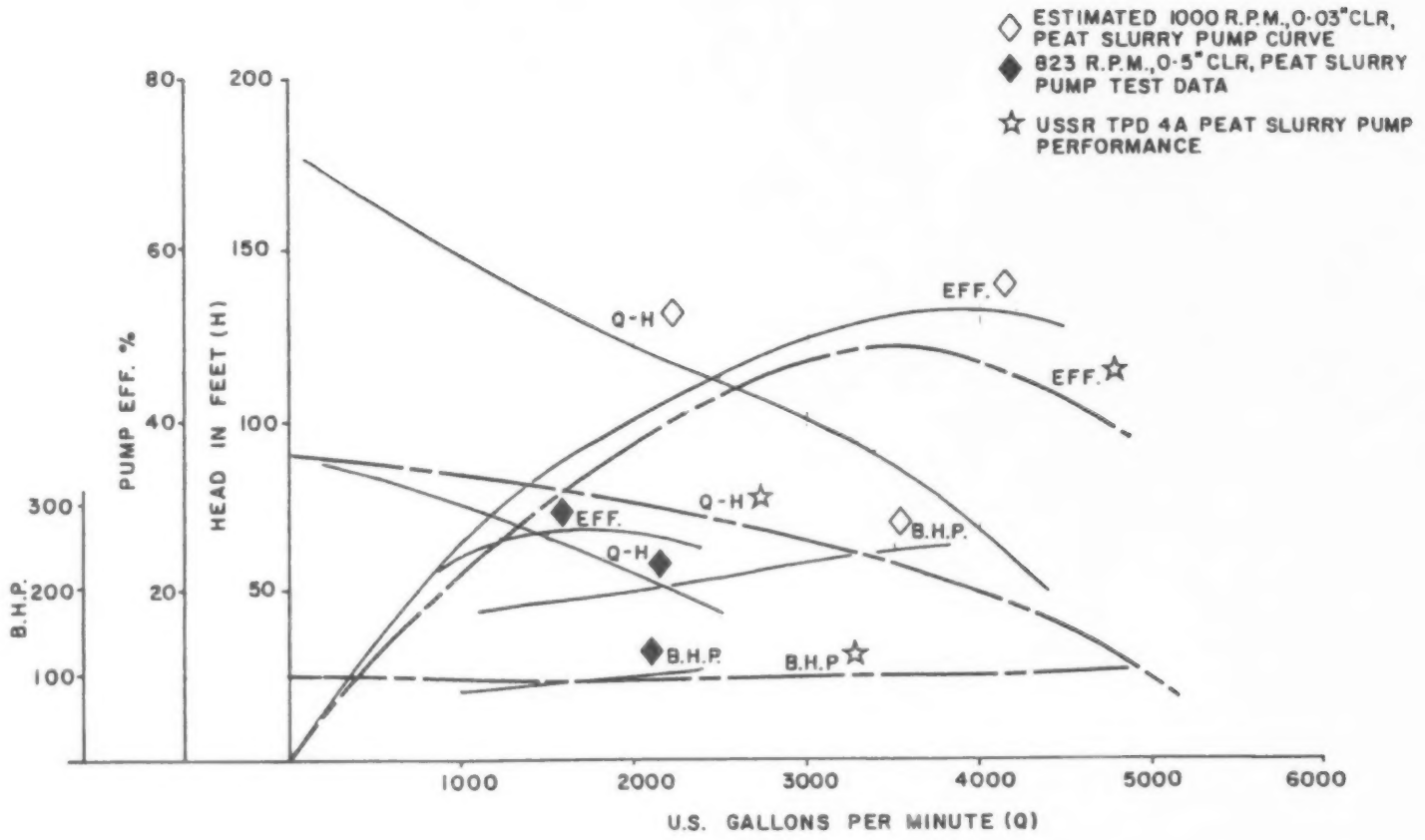


FIGURE 5-11 COMPARISON OF PEAT SLURRY PUMP PERFORMANCE ON PEAT SLURRY WITH PREVIOUS RUSSIAN PUMP

Source: (9)

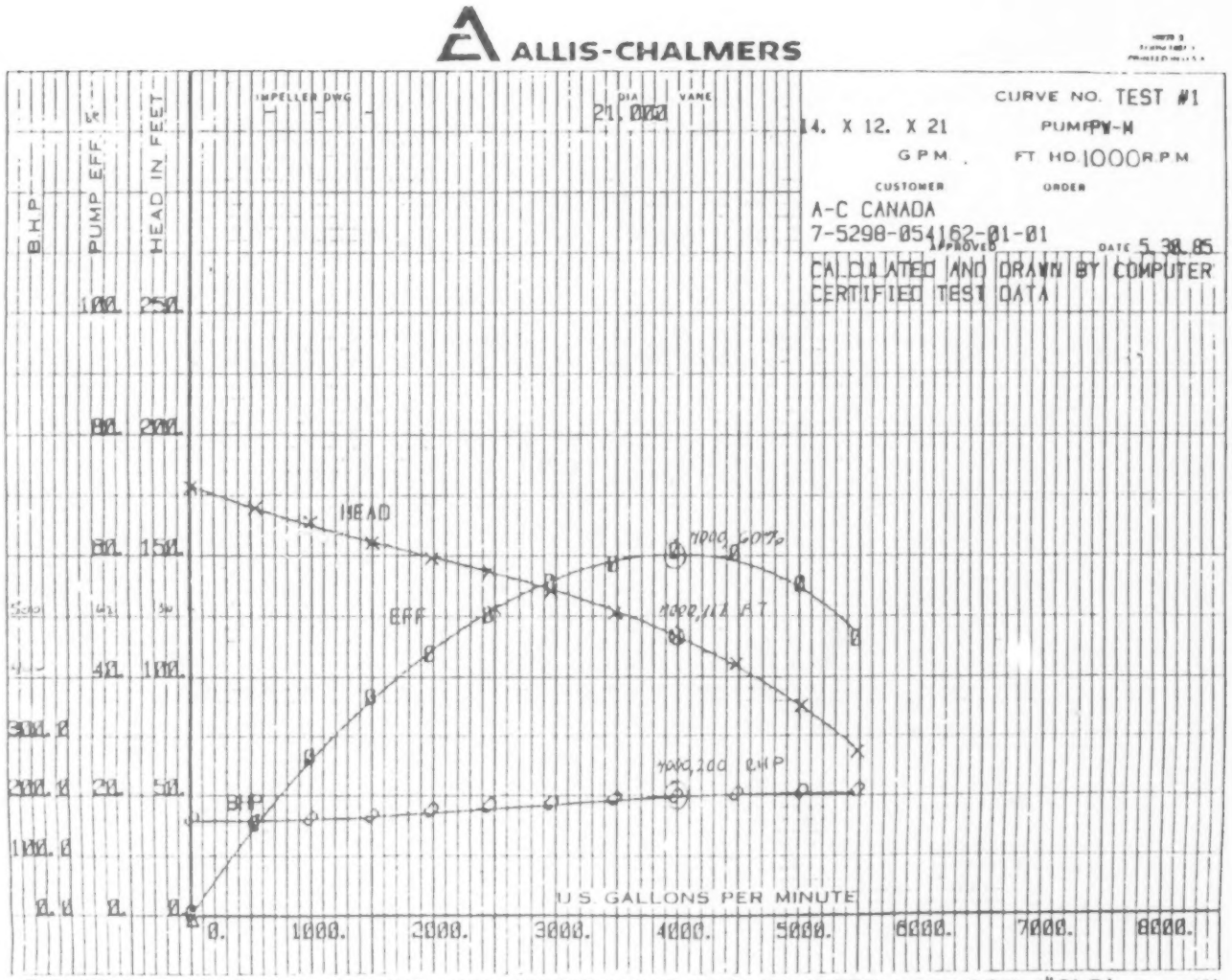


FIGURE 5-12 PEAT SLURRY PUMP SHOP PERFORMANCE DATA ON WATER (1000 RPM, 1" CLR) Source (3)

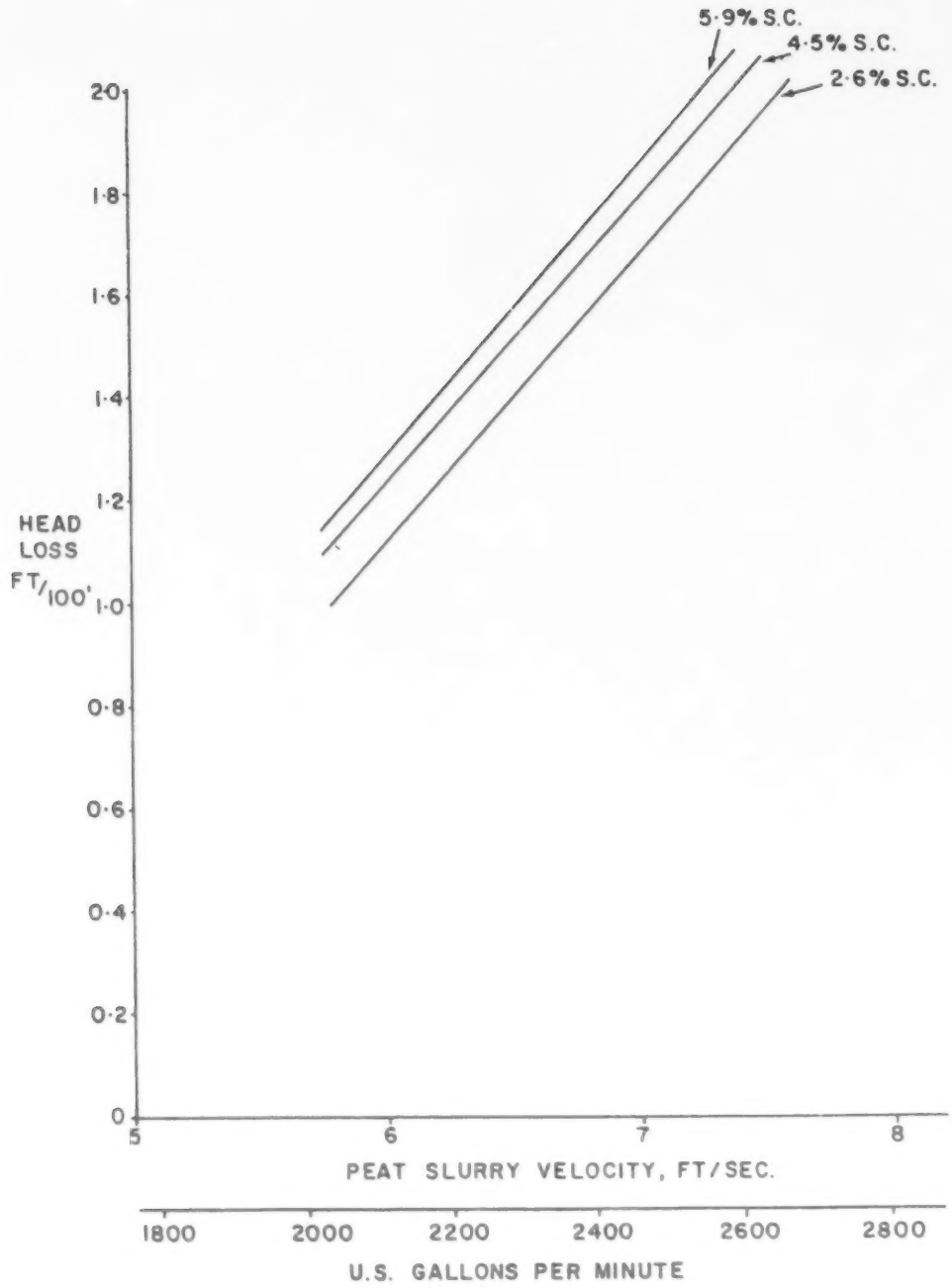


FIGURE 5-13 RELATION BETWEEN PRESSURE DROP AND PEAT SLURRY VELOCITY FOR DIFFERENT SLURRY CONCENTRATIONS (12" P.V.C. PIPELINE)

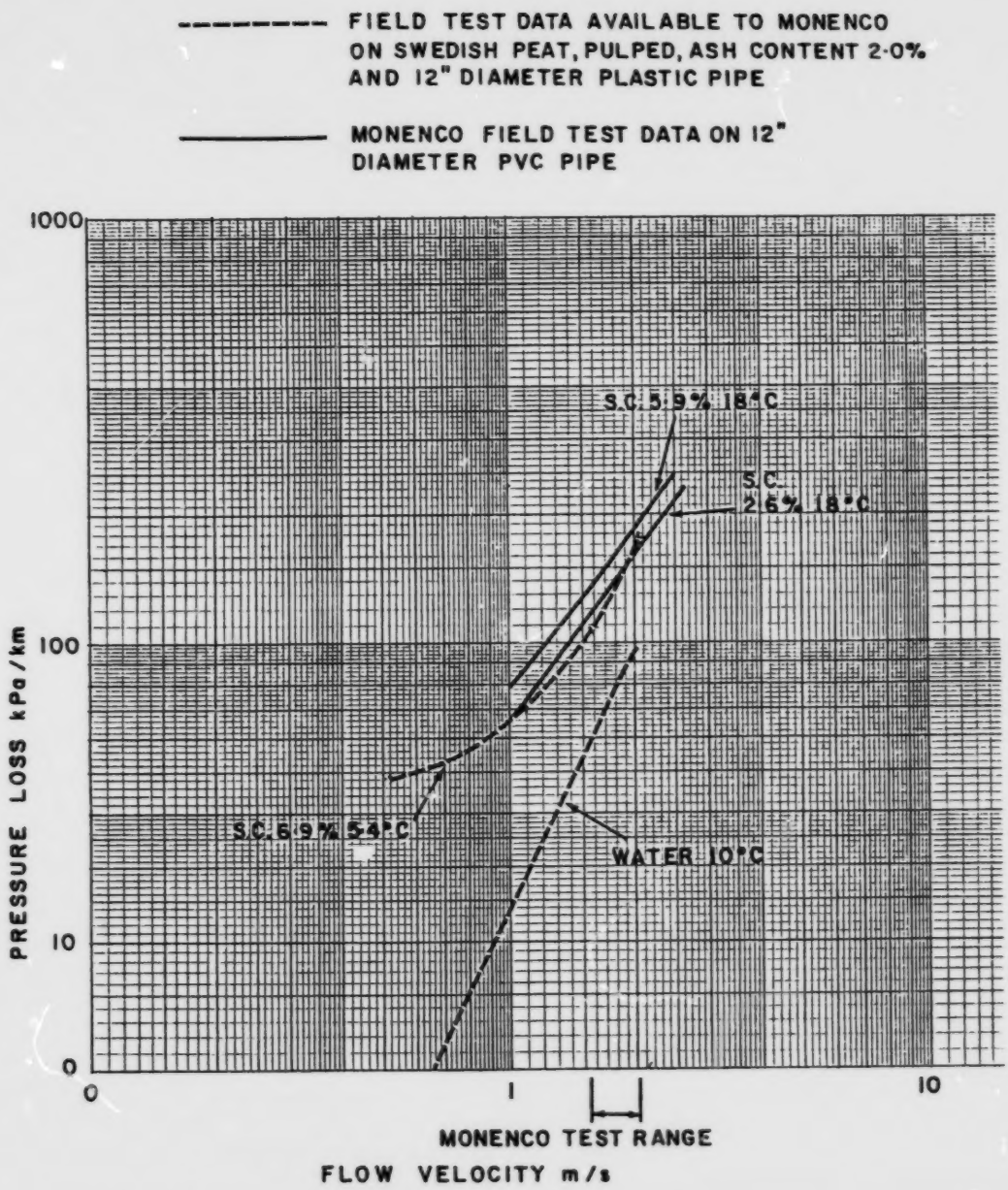


FIGURE 5-14 PRESSURE LOSS VERSUS FLOW VELOCITY FOR DIFFERENT SLURRY CONCENTRATIONS (COMPARISON OF MONENCO AND SWEDISH FIELD TEST DATA FOR 12" PIPELINE)

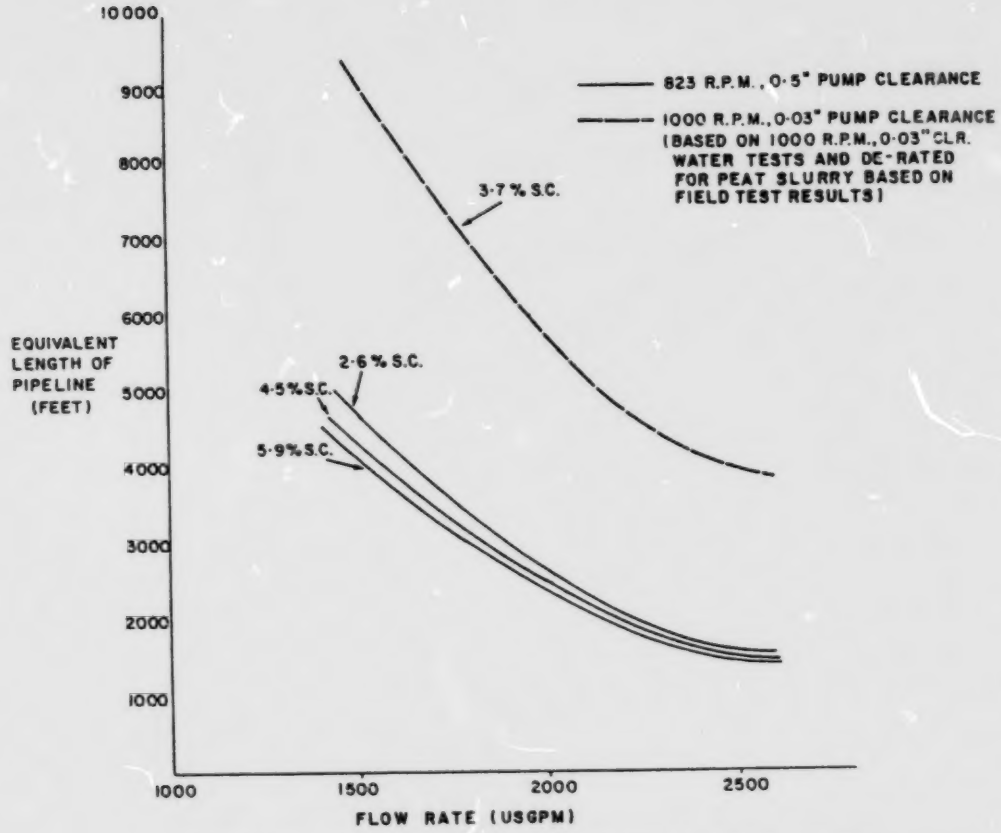
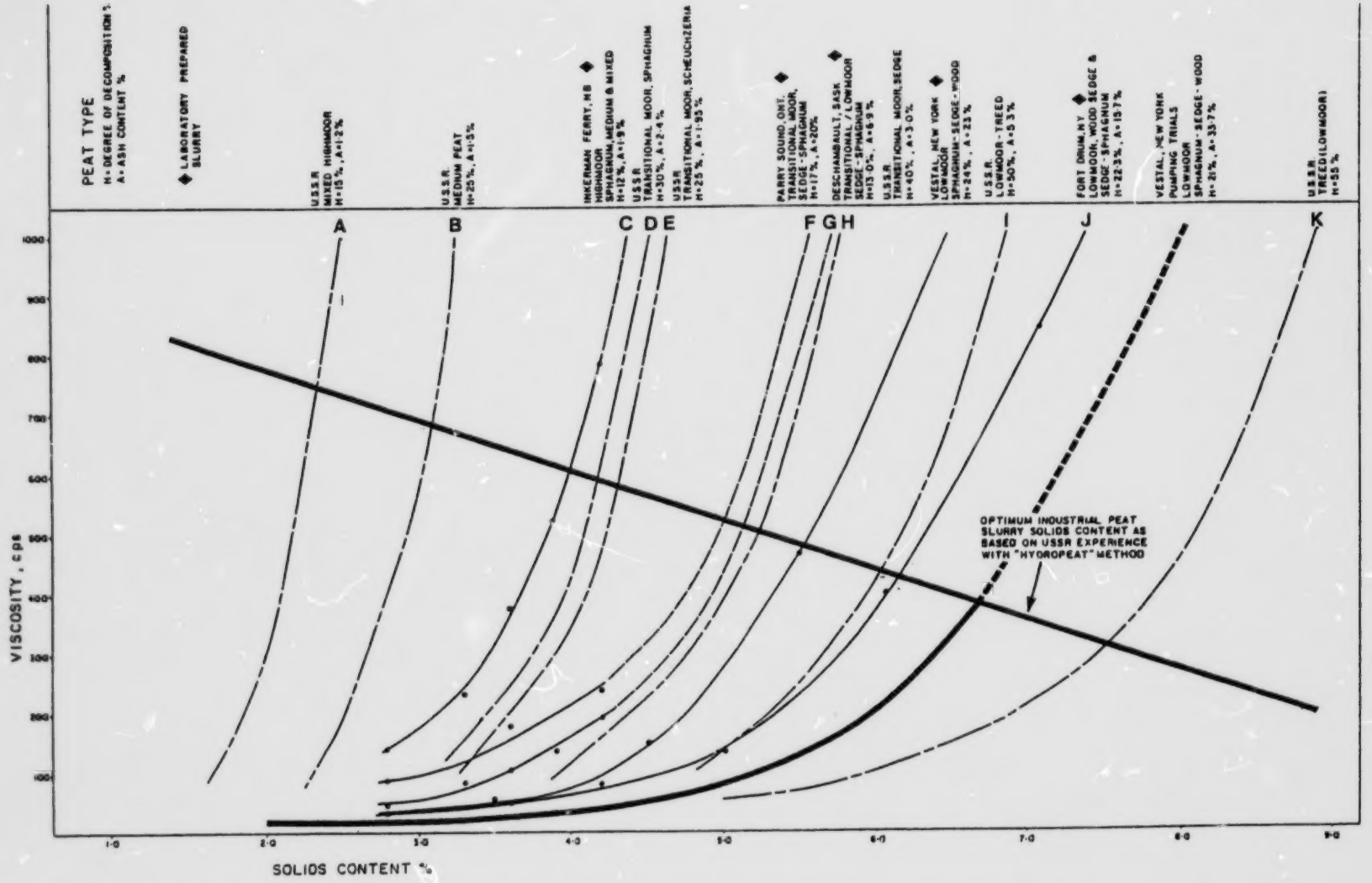


FIGURE 5-15 FLOW RATE VERSUS EQUIVALENT LENGTH OF PIPELINE FOR MONENCO PEAT SLURRY PUMP (12" DIAMETER PVC PIPELINE)



Source: (2,12)

FIGURE 5-16 COMPARISON OF THE RELATIONSHIP BETWEEN PEAT SLURRY VISCOSITY AND SOLIDS CONTENT FOR U.S.S.R. AND NORTH AMERICAN PEAT TYPES

Section 6
ASSESSMENT OF THE DEGREE OF MACERATION

INTRODUCTION

Three sets of experiments were conducted at the ORF Laboratory to assess the degree of peat maceration which occurs during pumping, and how this affects the settlability and dewaterability of the slurry. These were:

1. Particle size distribution;
2. Settlability; and
3. Dewaterability.

Slurry samples from the bottom, lower ash layer (pump tests 1 to 13) were used for moisture, ash and viscosity determinations along with four sump samples taken during the pump tests. Insufficient sample was available to do the tests for pump test 10. A sample taken from the sump while the propeller was removed was also analyzed. Particle size distribution was also done on a raw peat combined sample, composed of core samples taken during the detailed site analysis stage of the project. The sump samples, S1, S2, S3, S4 and SNP, were taken during tests 6, 7, 9, 10 and 12, respectively. The raw peat sample used in the particle size distribution test was a combination of samples K, L and D (see Appendix A).

Appropriate objectives, procedures and results for each of the three tests are presented in the following sections. However, since the results of all the tests are interrelated, analysis and discussion is presented at the end, in a single section.

PEAT SLURRY PARTICLE SIZE DISTRIBUTION TESTS

Objective

Particle size distribution tests were performed on raw peat, sump slurry and pumped slurry samples in order to estimate the degree of maceration that occurs during the various stages of peat wet mining.

Test Procedure

Tests were performed using a wet sieving technique similar to that outlined in the NRC Peat Testing Manual (1979). Each slurry sample was washed through a series of sieves, and the collected peat solids dried (at 105°C for more than 16 hours), and weighed for subsequent distribution calculations.

Results

Eighteen particle size distribution tests were carried out, the results of which are summarized in Table 6-1. Analysis and discussion is presented at the end of this Section ("Discussion of Results").

PEAT SLURRY SETTLABILITY TESTS

Theory

In systems that contain high concentrations of suspended solids, both hindered or zone settling and compression settling usually occur in addition to discrete and flocculant settling. This settling phenomenon that occurs when a concentrated suspension, initially of uniform concentration throughout, is placed in a graduated cylinder is shown in Figure 6-1 (Metcalf and Eddy, 1979). Peat slurry settlement was found to follow this phenomenon.

Because of the high concentration of particles, the liquid tends to move up through the interstices of the contacting particles. As a result, the contacting particles tend to settle as a zone or "blanket", maintaining the same

relative position with respect to each other. This phenomenon is known as hindered settling. As the particles in this region settle, a relatively clean layer of water is produced above the particles in the settling region. The rate of settling in the hindered-settling region is a function of the concentration of solids and their characteristics.

Objective

The objective of the peat slurry settlability tests was to ascertain the type and speed of settling which occurs following its removal by pumping to a holding pond.

Test Procedure

Settling tests were performed on seventeen peat slurry samples. Twelve samples were averaged test samples already analyzed for moisture content, ash content, and viscosity. Four sump samples taken while the propeller (stump deflector) was being used, and one sump sample taken after it was removed, were also tested.

Tests were performed according to a method recommended for sludge settling (Metcalf and Eddy Inc., 1979). Approximately 100 mLs of sample were placed in a graduated cylinder and the change in the height of the interface with time was recorded.

To calculate the settling velocity of the peat slurry, the point where hindered settling begins is noted from each settling curve. The underlined entries in Table 6-2 show the interface heights at which hindered settling began for each of the slurries tested. For example, for test 3, it can be seen from its settling curve (shown in Appendix G) that hindered settling began at an interface height of 3.8" after 60 minutes.

Subsidence (settling) velocity, V, from this portion of a settling curve is given by the formula:

$$V = \frac{\text{initial height - hindered settling height}}{\text{time}}$$

Therefore,

$$V \text{ (test 3)} = \frac{7.0 - 3.8}{60} \quad \text{inches/minutes}$$

$$= 0.053 \text{ inches/minute (3.2 inches/hour)}$$

Test Results

Lotus 1-2-3 software was used to analyze the recorded test data. Test results are presented in Tables 6-2 and 6-3, and settling graphs are given for the individual slurries in Appendix G. Analysis and discussion of the results and how they relate to other peat slurry properties can be found at the end of this Section.

PEAT SLURRY DEWATERABILITY TESTS

Theory

Vacuum filtration is often used to dewater a slurry by means of a porous medium which retains the solids while allowing the liquid to pass. The amount of solids which can be dewatered per unit time and the dryness of the cake formed are a function of the filterability of the slurry solids and porosity of the cake formed.

The rate of filtration of sludges has been formulated according to Poisenille's and D'Arcy's laws and can be expressed as (Eckenfelder, 1966):

$$\frac{t}{V} = \frac{urc}{2PA^2} V + \frac{uRm}{PA} \qquad \text{Eqt. (1)}$$

where V = Volume of filtrate,
t = Time,
P = Pressure,
A = Filtration Area,
u = Filtrate Viscosity,
r = Specific Resistance, and
c = Weight of solids per unit volume of filtrate.

From Eqt. (1) a linear relationship results from a plot of t/V versus V. The specific resistance can be computed from the slope of this plot:

$$r = \frac{2\ b\ PA^2}{uc} \qquad \text{Eqt. (2)}$$

where b is the slope of the plot t/V versus V. The weight of solids per unit volume of filtrate, c, is computed from the relationship:

$$c = \frac{1}{c_i/(100-c_i) - c_f/(200-c_f)} \qquad \text{Eqt. (3)}$$

where c_i = Initial moistue content of the slurry
c_f = Final moisture content of the slurry

The specific resistance of the slurry is a measure of its dewaterability.

Objective

To determine degree of dewaterability of peat slurry produced by the wet mining of peat.

Test Procedure

Filtration characteristics of slurries can be obtained in the laboratory by the Buchner funnel test, which permits the determination of specific resistance. Figure 6-2 shows the Buchner funnel assembly used for these tests.

A well mixed slurry sample is transferred to the funnel and a vacuum is applied. Filtrate volume, after specific time intervals, is recorded until vacuum break. Using initial and final solids concentration in the feed slurry and cake, the specific resistance can be calculated.

For a sample calculation, take test 7.

Initial Moisture Content = 95.42%
Final Moisture Content = 77.32%

c, which is the weight of solids per unit volume of filtrate is calculated according to Eqt. (3).

$$c = \frac{1}{95.42/(100-95.42) - 77.32/(100-77.32)}$$

$$= 0.0574$$

Pressure, P = 25" Hg = 880 g/cm^2
Filtration Area, A = 44.18 cm^2
Filtrate Viscosity = 0.01
Slope, b = 0.000083 sec/cm^6

Therefore,

$$r = \frac{(2)\ (0.00083)\ (880)\ (44.18)^2}{(0.01)\ (0.0574)}$$

$$= 4.967 \times 10^5\ sec^2/gram$$

Test Results

Results for each of the seventeen dewaterability tests performed are given in Appendix G. Time, T, is expressed in minutes and filtrate volume, V, in millilitres. Plots for each of these tests are also presented in Appendix H.

Table 6-4 shows the essential data required for the calculation of the peat slurry specific resistance.

Results are discussed in the next section, together with those from the settlability and particle size distribution tests.

DISCUSSION OF RESULTS

The most obvious indication of maceration is the percentage of large size particles in the slurry, i.e. those greater than 2 mm. The quantity of particles greater than 2 mm was reduced by 55% by the pump and pipeline when the propeller (stump deflector) was used. A similar percentage reduction was experienced when the propeller was not used, though total particle weights are somewhat higher at both sampling locations. From analysis of one solid peat sample, it appeared that hydromonitoring did not contribute significantly to maceration of the peat type tested, at a particle level, although it was obviously important in the breakup of large clumps of peat. However, this appears anomalous and should be confirmed with further testing on different peat types and different degrees of decomposition.

Analysis of peat slurry settlability and dewaterability should be done in conjunction with solids content, viscosity and particle size distribution data. A series of computer generated graphs using all the data reported are discussed in the following paragraphs. Table 6-5 summarizes the data.

Specific resistance, which is measure of dewaterability, decreases with increasing solids content as shown in Figure 6-3. This is as expected, and, since slurry viscosity increases exponentially with solids content, dewaterability decreases exponentially with slurry viscosity (see Figure 6-4). Settlability appears to increase linearly with increasing dewaterability, as shown in Figure 6-5.

An interesting relationship between peat slurry solids content and subsidence velocity (settlability) is presented in Figure 6-6. Settlability decreases exponentially with increasing solids content, with a dramatic reduction taking

place between 2 and 3% total solids. A similar relationship was found to occur between the settlability rate and viscosity (Figure 6-7).

PRELIMINARY CONCLUSIONS

Both settlability and dewaterability are peat slurry properties which will have a significant effect on wet peat mining operating conditions. Both settlability and dewaterability decrease with an increase in slurry solids content. Settlability decreases rapidly between 2% and 3% total solids. Dewaterability also decreases with increasing solids content, through this relationship appears to follow a less dramatic curve than does settlability, which is exponential. Essentially, a 2% solids slurry settles between six to nine times faster than a 5 to 6% solids slurry, although only two to three times the quantity of peat has been mined in the latter. The dewaterability rate decreases by a factor of 2 to 2.5 when the slurry solids content is doubled.

Settling is a cheap water removal process. The major costs associated with it are land area and time requirements. Dewatering is a mechanical process which needs energy input. Very preliminary analysis of settlability data suggests that the degree by which the solids content of the settled peat is increased over the slurry pumped solids content is very small. However, a complete analysis featuring a detailed comparison between the benefits of dewatering versus settlability from both a process and economic standpoint is required.

TABLE 6-1 - Particle Size Distribution in Peat Slurry Samples

Particle Size	Test Number																	
	Solid Peat	Sump No Prop	Sump 1	Sump 2	Sump 3	Sump 4	1	2	3	4	5	6	7	8	9	11	12	13
	Percent Distribution by Weight																	
> 2 mm	25.60	31.02	26.42	33.66	28.29	21.86	8.38	5.54	12.10	12.75	5.01	13.92	14.04	21.62	17.80	11.03	13.15	18.06
< 2 mm & > 1 mm	5.15	6.61	6.16	6.23	6.49	5.05	4.61	6.26	10.31	7.54	4.56	9.06	8.67	8.68	10.90	4.34	6.61	5.68
< 1 mm & > 0.6 mm	18.15	5.39	4.85	4.01	4.52	4.26	3.35	7.50	8.12	6.21	5.35	5.81	8.56	4.47	5.24	4.64	7.08	5.46
< 0.6 mm & > 0.149 mm	7.10	10.81	24.42	26.74	18.20	19.79	26.14	30.24	30.71	36.42	27.16	19.39	28.15	23.02	20.34	24.80	27.47	22.68
< 0.149 mm & > 0.063 mm	15.30	22.21	9.95	5.17	8.81	12.65	11.35	11.96	12.16	10.18	15.63	12.03	7.07	11.26	10.09	14.39	12.75	14.55
< 0.063 mm	28.70	23.95	28.20	24.18	33.69	36.39	46.17	38.49	26.59	26.90	42.29	39.79	33.51	30.95	35.46	14.79	32.94	33.57

TABLE 6-2 - Peat Slurry Settlability Tests

TEST NO :	1	2	3	4	5	6	7	8	9	11	12	13	S1	S2	S3	S4	SHP
TIME(MIN)	INTERFACE HEIGHT (INCHES)																
0	6.7	7.0	7.0	7.1	7.1	5.5	7.0	6.6	6.9	7.0	6.4	6.4	7.5	7.3	7.3	7.4	7.5
5	6.6	5.5	6.4	6.7	3.9	5.5	6.9	6.4	6.7	6.7	6.4	6.4	7.4	7.0	7.0	7.3	4.6
15	6.5	4.7	5.8	6.4	3.4	5.5	6.8	6.4	6.7	6.6	6.3	6.4	7.3	7.0	7.0	7.2	4.6
30	6.4	3.8	4.6	5.7	2.9	5.4	6.7	6.3	6.7	6.2	6.2	6.3	7.0	6.7	6.7	7.0	4.2
60	6.2	3.3	3.8	4.6	2.5	5.3	6.6	6.1	6.5	5.5	6.1	6.2	6.3	6.4	6.1	6.7	4.0
120	5.8	3.0	3.5	4.1	2.4	5.2	6.2	5.8	6.2	4.6	5.9	6.1	5.2	5.6	5.5	5.9	4.0
240	5.1	2.9	3.4	3.9	2.3	5.1	5.6	5.2	5.7	4.1	5.5	6.1	4.6	5.0	4.9	5.0	3.9
420	4.5	2.9	3.4	3.8	2.3	4.9	5.1	4.9	5.2	3.9	4.9	5.8	4.3	4.9	4.6	4.5	3.7
740	4.1	2.8	3.3	3.7	2.3	4.7	4.8	4.8	5.0	3.8	4.5	5.5	4.2	4.8	4.6	4.3	3.7
1380	4.0	2.8	3.3	3.7	2.3	4.6	4.7	4.7	4.9	3.7	4.3	5.4	4.1	4.8	4.6	4.3	3.7
1620	4.0	2.8	3.3	3.7	2.3	4.6	4.7	4.7	4.9	3.7	4.3	5.3	4.1	4.8	4.6	4.3	3.7

TABLE 6-3 - Subsidence Velocities for Peat Slurries

Test Number	Subsidence Velocity (inches/hour)
1	0.4
2	3.7
3	3.2
4	1.5
5	4.6
6	0.2
7	0.35
8	0.35
9	0.3
11	1.2
12	0.21
13	0.2
Sump 1	1.15
Sump 2	0.85
Sump 3	0.9
Sump 4	0.6
Sump - No Prop.	3.5

TABLE 6-4 - Specific Resistance of Peat Slurry to Dewatering

TEST NO	INITIAL MOISTURE CONTENT (%)	FINAL MOISTURE CONTENT (%)	FILTRATE CONC,c	PRESSURE (INCHES Hg)	SLOPE b (SEC/CM 6)	SPEC RESISTANCE (SEC 2/g)
1	95.8	75.87	0.0505	25	0.000069	471086
2	97.45	76.3	0.0286	25	0.000056	667983
3	97.83	81.46	0.0246	25	0.000047	657083
4	97.29	83	0.0322	25	0.000067	710374
5	97.61	79.36	0.0270	25	0.000065	823747
6	93.69	81.32	0.0953	25	0.000124	448406
7	95.42	77.32	0.0574	25	0.000083	498830
8	95.54	85.44	0.0643	25	0.000124	664550
9	95.55	82.98	0.0683	25	0.000075	429136
11	96.9	84.68	0.0389	25	0.000064	563285
12	95.7	80.53	0.0552	25	0.000091	565878
13	94.62	79	0.0723	25	0.000092	437458
S1	95.79	75.24	0.0507	25	0.000086	582573
S2	96.89	86.27	0.0402	25	0.000110	935764
S3	96.44	82.75	0.0449	25	0.000111	850915
S4	96.32	84.83	0.0486	25	0.000080	618678
SNP	97.68	80.67	0.0264	25	0.000051	660212

TABLE 6-5 - Summary of Peat Slurry Physical Properties

TEST NO	SOLIDS (%)	MOISTURE (%)	ASH (%)	VISCOSITY (cP)	SUBSIDENCE VELOCITY (INS/HR)	SPECIFIC RESISTANCE (SEC 2/g)
1	4.2	95.8	39	46	0.4	471086
2	2.6	97.4	37.1	30	3.7	667903
3	2.2	97.8	29.7	30	3.2	657083
4	2.7	97.3	25.5	30	1.5	710374
5	2.4	97.6	36.9	32	4.6	823747
6	6.3	93.7	33.1	230	0.2	448406
7	4.6	95.4	31.3	55	0.35	498830
8	4.5	95.5	28	77	0.35	664558
9	4.5	95.5	32.5	53	0.3	429136
11	3.1	96.9	33.2	45	1.2	563285
12	4.3	95.7	32.7	49	0.21	565878
13	5.4	94.6	33.8	185	0.2	437458
S1	4.2	95.8	30.3		1.15	582573
S2	3.1	96.9	28.2		0.85	935764
S3	3.6	96.4	29.3		0.9	858915
S4	3.7	96.3	36.4		0.6	618678
SNP	2.3	97.7	32.2		3.5	668212

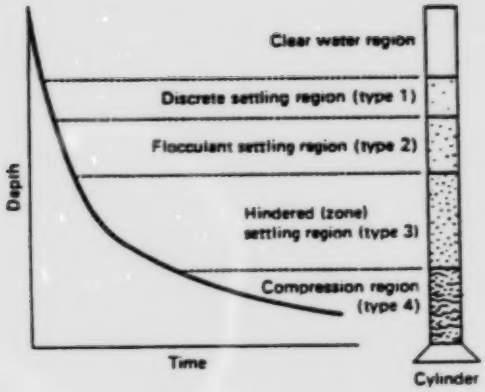


FIGURE 6-1 - Graduated Cylinder

(Metcalf and Eddy, 1979)

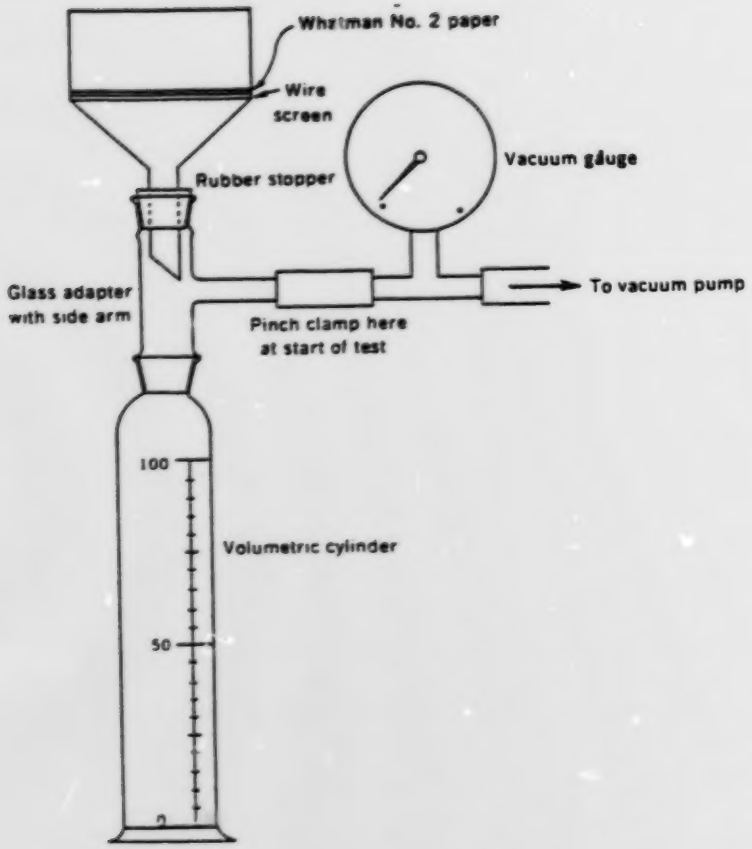


FIGURE 6-2 - Buchner Funnel Assembly for Determination of Slurry Filterability (Eckenfelder, 1966)

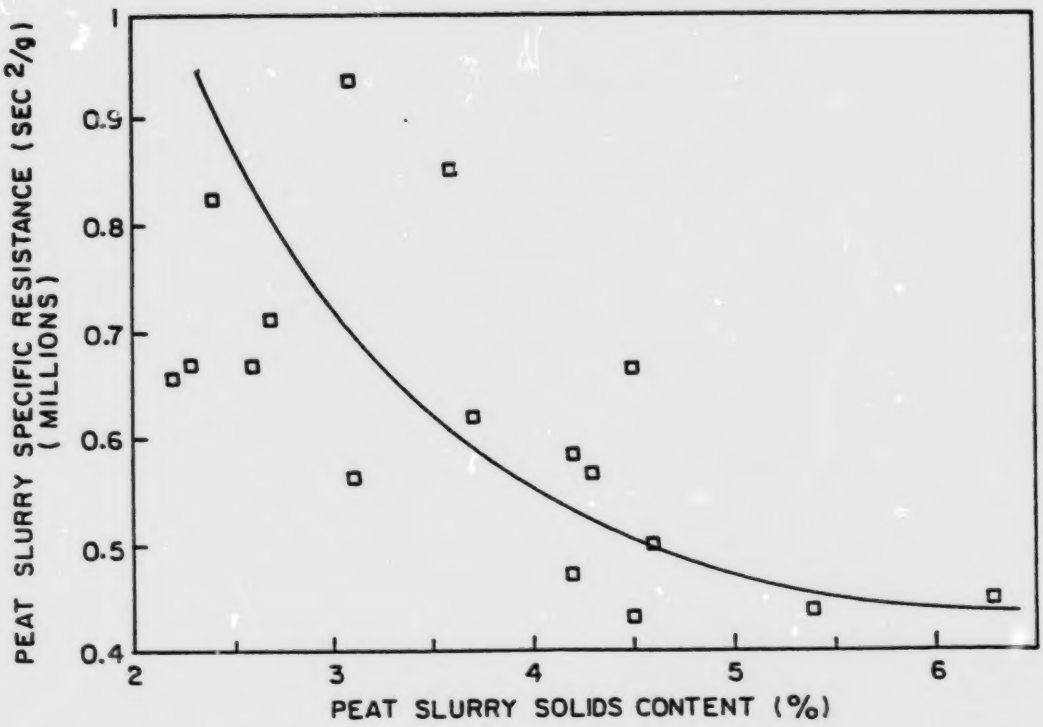


FIGURE 6-3 - Peat Slurry Solids Content vs. Specific Resistance

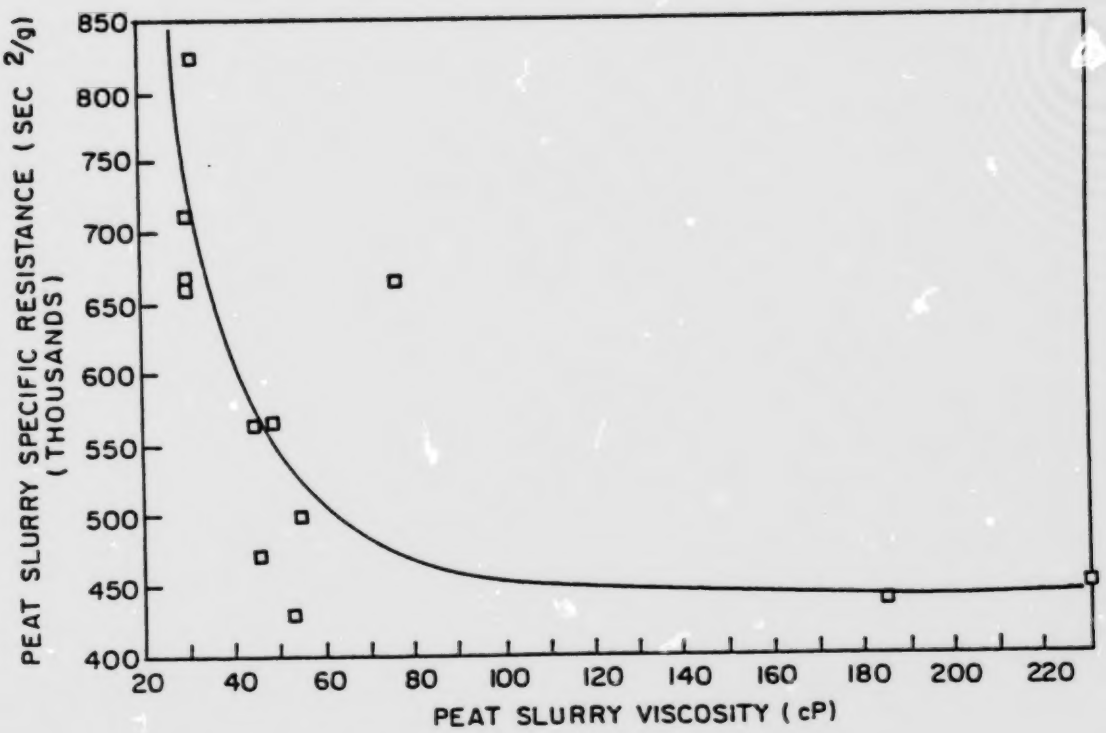


FIGURE 6-4 - Peat Slurry Viscosity vs. Specific Resistance

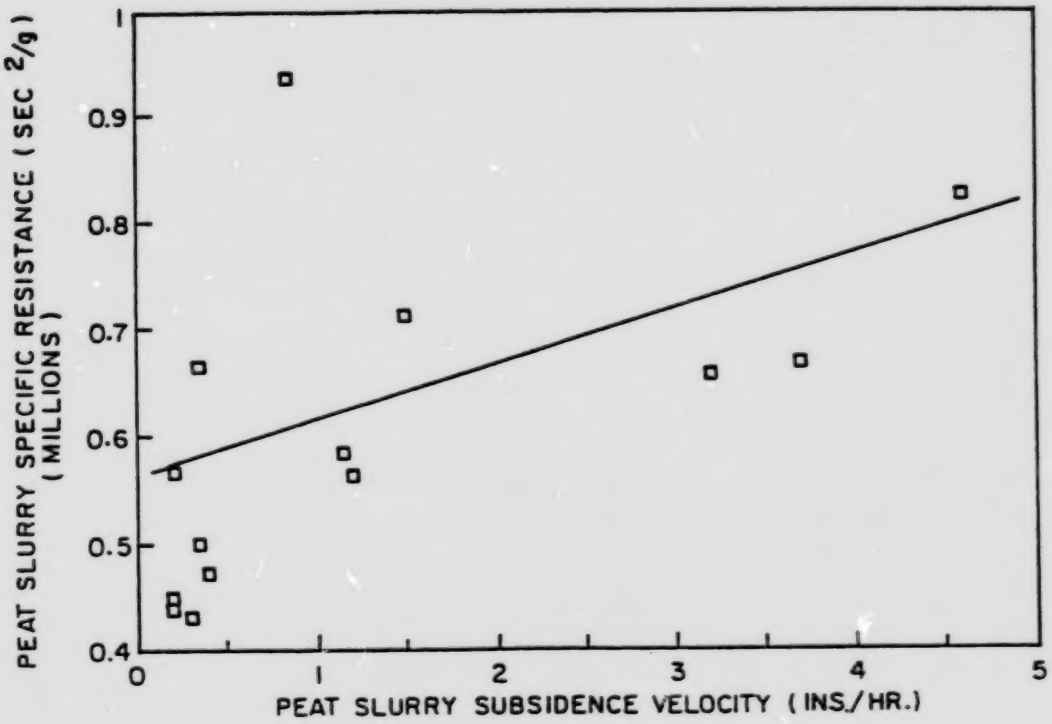


FIGURE 6-5 - Peat Slurry Subsidence Velocity vs. Specific Resistance

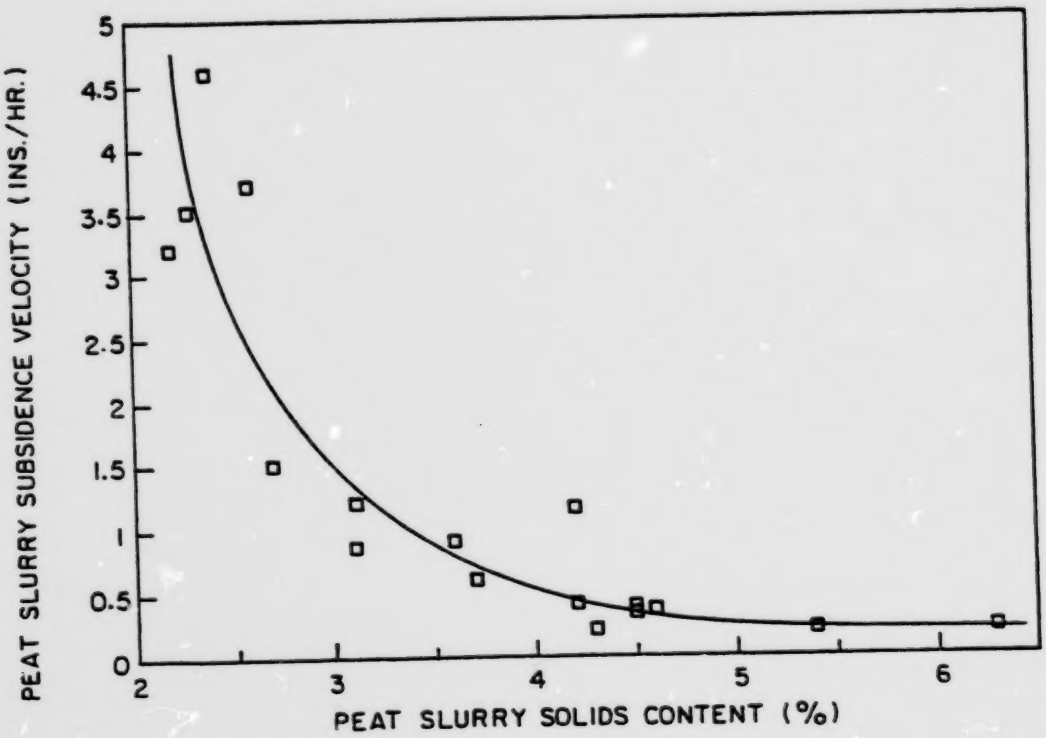


FIGURE 6-6 - Peat Slurry Solids Content vs. Subsidence Velocity

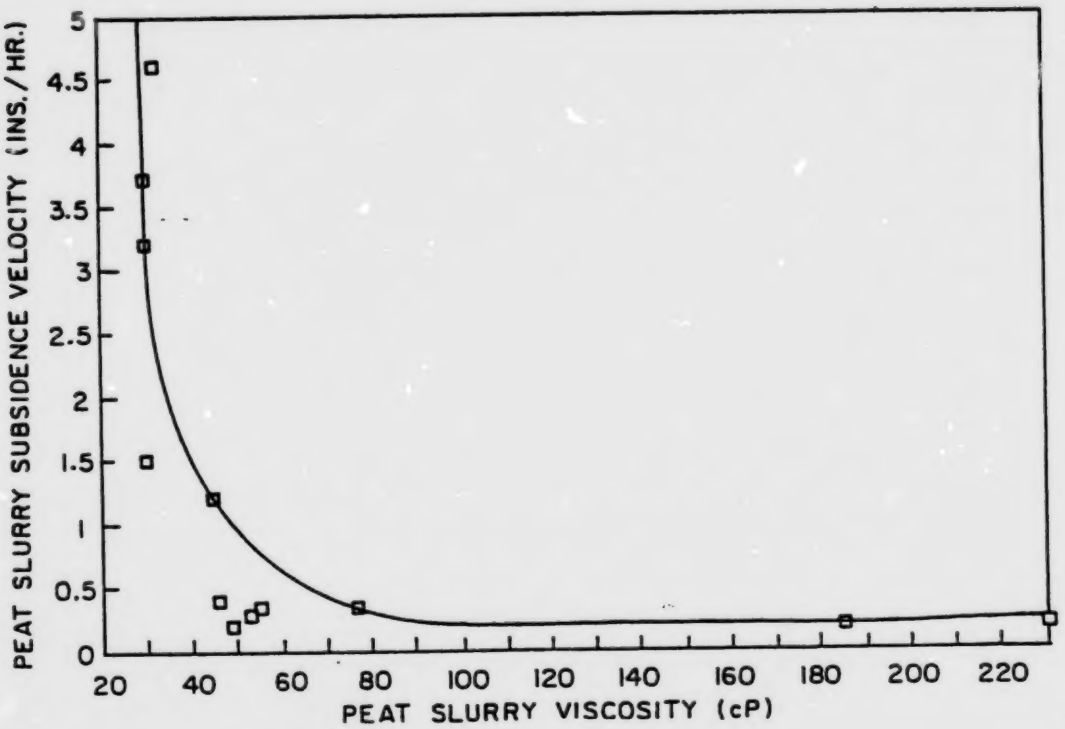


FIGURE 6-7 - Peat Slurry Viscosity vs. Subsidence Velocity

Section 7
SUMMARY AND FINDINGS

1. The peat slurry pumping demonstration test was completed during summer, 1985 on a New York peatland site. Besides determining the performance of the peat slurry pump and pipeline system, the field test provided a demonstration of wet peat mining technology, including an evaluation of the effectiveness of preparing peat slurries using a high pressure water jet system. The major parameters regarding the pumping and pipeline transport of peat slurry were studied.

2. Delays in project funding and start-up until late fall/early winter 1984/85 prevented the use of a virgin peatland because of anticipated further delays in obtaining environmental clearances and the period of time required for bog drainage after ditching. Therefore, peatland site selection activities were directed towards previously drained peatlands or existing peat harvesting operations, to conform to the project schedule. Final selection of an acceptable site for the demonstration project followed a review of available peat resource information for the State, discussions with various bog owners and operators, site visits to six "most likely" locations and initial site sampling. The results of this investigation were discussed in the interim "Site Selection Report" and the Bob Murphy bog near Vestal, N.Y. was selected as the most suitable location for the testing. Good access, location near a town, all of the bog controlled by one landowner, availability of all support facilities already on the property or nearby and an existing mining permit in place to allow removal of the peat, etc. were important factors affecting final selection.

3. The following factors were considered in evaluating the suitability of the Bob Murphy bog:

- o the total area at the deposit was 3.2 acres (1.3 ha), the peat thickness varied from 13.8 to 16.1 ft (4.2 to 4.9 m), considered adequate for test purposes;
- o the deposit was characterized by lowmoor peatland (fuel peat);
- o there were no trees and little shrubs on the surface and no surface vegetation removal (e.g. trees) for the test was needed (lower preparation and site reclamation costs);
- o the water supply was indicated to be adequate by the property owner (who was quite familiar with the local aquifers, e.g. Town of Vestal wells on his property);
- o a suitable slurry containment area was available;
- o no environmental problems were foreseen because the surrounding property was owned by Mr. Murphy who had an existing mining permit. Mr. Murphy also had machine shop and maintenance facilities, skilled mechanical tradesman and equipment, etc. available at the site from the nearby gravel and concrete operations;
- o subsequent further sampling of the site revealed higher ash values than originally indicated and it was necessary to carry out a detailed sample analysis of the site to finally select a peat layer with lowest ash content (range of 10 to 22% and an average of 18.2%, dry basis) situated about 6.6 to 11.8 ft (2.0 to 3.6 m) from the surface;
- o the moisture content averaged 82.3% or equivalent to that of drained peatland; and
- o the degree of decomposition varied from 16% up to 24%, averaging 20.1% since most of the deposit was composed of fuel grade peat (an average von Post degree of humification of H6.6).

4. The following site preparation activities were carried out prior to the test:

- o 2,350 ft of access roads were constructed around the site (approx. 715 m);
- o a water supply channel was excavated (500 ft long x 45 ft wide and 7 ft in depth);
- o a 22,400 yd^3 peat slurry reservoir was constructed using on-site materials, mostly clays, silts and gravels scraped from the floor of the reservoir for construction of the berms;

- o the surface of the peat deposit (approx. 450 ft x 250 ft) was disked prior to moving equipment on-site, to remove the growth of tall grasses and some shrubs; and

- o prior to performing the pumping trials, the entire mining area (pit, trench, sump, etc.) was laid out on the bog surface using wooden stakes; in addition lengths of 20 ft graduated steel conduit were driven into the peat and used as depth indicators during the mining activities.

5. Various pieces of equipment had to be fabricated and/or assembled at site including:

- o a support barge was fabricated with a double-drum winch and 32 ft boom arrangement to lower and raise the peat slurry pump into and out of the mining sump;

- o a control valve station was constructed adjacent to the barge and included a stop/start electrical control for the pump, two valves to control slurry flow and an air evacuator system. The main purpose of the valves was to control the slurry flow rate during pumping operations. The air evacuator system was installed to study possible air entrainment problems in the slurry pump/pipeline system;

- o the hydromonitor system was assembled on site and includes the main low pressure water supply pump (2000 USGPM) supplying water through 100 ft of 10 inch pipeline to two high pressure booster pumps, and from there via 200 to 270 ft of 6 inch steel pipe and rubber hoses to the two hydromonitors (water jets);

- o the electric power to operate the peat slurry pump/macerator was supplied by a GMAC 470 hp diesel-electric generator set. Energy from the generator set was fed by power cable to the 150 hp, 1800 rpm, 460 V electric motor mounted on the slurry pump;

- o a clean water supply was required for the peat slurry pump at a rate of 5 USGPM for lubrication of the main pump bearings;

- o 860 ft of 12 inch PVC pipe was assembled to convey peat slurry from the control valve station to the spill tank located at the end of the pipeline. The individual lengths of pipe were connected either by cementing the pipes and couplings, or by a friction fit. In addition, a number of joints, particularly the elbows, were covered with small amounts of concrete to improve stability of the pipeline during operation. At the discharge end of the pipeline, a cylindrical tank was installed in the wall of the slurry reservoir to act as a "spill box" and a support for the discharge end of the pipe; and

6. During the peat slurry pumping trials the following major mining and pumping aspects were studied:

   - the effectiveness of peat slurry preparation using high pressure water jets and the use of the peat slurry pump/macerator as a mining (and a partial processing) tool;
   - the performance characteristics of the Monenco designed peat slurry pump and pipeline system (flow rates, dynamic head, pressure loss, efficiency, power requirements, etc.) were determined under actual field conditions;
   - the effect of the stump deflector was studied, and air entrainment in the system (a problem reported in previous USSR practice requiring an air evacuator arrangement for the pipeline) was assessed. An aspect of the pump design, suggested by the pump manufacturer, involved a variable clearance between the wear plate and impeller to allow internal re-circulation of slurry which varied capacity of the pump. By increasing the clearance, increased re-circulation occurred and the air-handling ability of the pump increased. The clearance could be varied from 0.03 to 1.0 inch;
   - an evaluation of the physical properties of the peat slurry was made on samples taken before and after the slurry pump, viz viscosity, solids content, ash content, degree of decomposition and particle size distribution; and
   - an evaluation was made of the degree of maceration, settability and dewaterability of peat slurries as prepared by the hydromonitor and peat slurry pump/macerator system.

7. During removal of the top layer of higher ash content peat, the peat slurry pump operated at a nominal 800 rpm with a one inch clearance between the impeller and wear plate. These initial operating parameters demonstrated the following:

   - the pump flow rate varied from 1040 to 1760 USGPM (236 to 400 m^3/hr) and, as expected, was generally lower than the previous water performance tests performed at the manufacturer's plant. A total of 1,146,415 U.S. gallons (4,339.2 m^3) of peat slurry, at an average of 6.4% solids concentration by weight, was pumped during the 11 test "runs";
   - the total head developed by the pump (average H=35.5 ft) was also lower than the previous water test (H=44.5 ft) at the best efficiency point. However, the average slurry solids concentration was considerably higher (6.4%) than expected (4%);

- at the best efficiency point, the pump brake horsepower was higher (77 Bhp) than the water test data (70 Bhp). The 10% increase in brake horsepower can be attributed to the difference between the viscosity of the peat slurry and the viscosity of water;

- the field test performance data showed that the head produced by the pump during the pumping trials was 20% lower than the actual shop performance test results on water. This result was expected by Monenco and considered acceptable based on the previous USSR experience;

- a low pump efficiency was observed, averaging 15.7% (lower than Monenco's estimated 20% reduction in efficiency between water and peat slurry) with an average 10% higher brake horsepower requirement, and was attributed to low pumping capacities obtained when pumping surface layer peat containing much plants and root material. The determination of pump efficiency included the power demand to operate the complete pumping, macerating and external propeller units and, as well, the energy losses in the power transmission system (motor to pump drive shaft) were not evaluated and therefore efficiency was not established on an absolute basis; and

- after a total operating time of 14 hours on varying characteristics of the surface layer peat, the pump was secured on surface and dismantled for inspection by Monenco and the manufacturer's pump specialists. Generally the mechanical condition of the pump was good, and no damage, wear or corrosion was noted, except slight wear to the main nylon shaft bearings. The water lubrication system for the main shaft bearings appeared to perform well.

8. During removal of the lower peat layer (lower ash content), the peat slurry pump operated at a nominal 800 rpm with a 0.5 inch clearance between the impeller and wear plate. Ten of the thirteen "runs" (changes in capacity) were with the stump deflector attached, and three "runs" were without the stump deflector ("propeller"). When comparing pump performance (with the stump deflector attached) on peat slurry to the shop tests on water, the following was noted:

   - at the medium designed pump clearance (0.5"), approximately 582,100 U.S. gal. (2203 m^3) of peat slurry were pumped during ten test "runs". The pump capacity varied from 1620 to 2220 USGPM (370 to 505 m^3/hr) of peat slurry, averaging 3.7% solids concentration. This pump capacity was only 15% lower on average than the comparable water test capacity, at the best pump efficiency point, and was assessed as acceptable;

- o at the best efficiency point, the slurry pump developed a dynamic head of 58 feet with an efficiency of 28%. These figures are 9% and 8% lower respectively, in comparison to pro-rated pump performance data on water (H=63.5 feet, efficiency=30%). From this point of view the pump performed satisfactorily; and

- o at the best efficiency point, the average pump brake horsepower during the field test was higher (95 Bhp) than the pump performance on water (78.5 Bhp pro-rated from manufacturer's test data at 800 rpm, 1" clearance). The 21% increase in brake horsepower can be attributed to the difference between the viscosity of the peat slurry and the viscosity of water.

Pump performance (nominal 800 rpm, 0.5 inch clearance) with the stump deflector during the ten test "runs" as compared to without the stump deflector during the last three test "runs" gave the following results:

- o at the same pump capacity, a small improvement (2%) in pump efficiency was noted;

- o 3% lower brake horsepower was required when the stump deflector was removed;

- o the dynamic head produced by the pump, with and without the stump deflector, was found to be the same (possibly due to a limited number of test data);

- o previous performance tests on water, with and without the stump deflector, showed a 2.1% increase in pump efficiency and a 3.8% decrease in dynamic head, without the stump deflector; and

- o the previous USSR data indicated a 5% change a dynamic head when the stump deflector was removed.

9. Representative peat slurry samples were prepared and analysed daily for solids content, ash content and viscosity in the site laboratory. Solids content of the slurry varied between 1% and 7.1% (averaging 3.7%). For each test (change in pump rpm, impeller-wear plate clearance), the solids concentration during the three runs (changes in capacities) varied slightly. This was to be expected. The ash content of the slurry varied between 22.8% and 40.2%. The ash content of the slurry was somewhat higher (averaged 33.7%) than expected based on the laboratory results on the in-situ peat (average 18.2% dry basis). It is possible the higher than expected range of ash in the peat slurry was a result of some

residual contamination of the lower ash content layer (10 to 22% ash) by the upper higher ash content layer (35 to 45% ash) removed earlier. Peat slurry viscosity results as determined by the site laboratory were almost the same as laboratory results obtained earlier on the in-situ peat samples taken to characterize the site.

10. To obtain plots, data from the lower layer tests was grouped because of distribution according to solids concentration levels of 2.6%, 4.5% and 5.9%, by weight. The pump/pipeline performance data (dynamic head versus capacity and head loss versus peat slurry velocity), for different peat slurry solids concentrations, showed that the pump dynamic head decreased with an increase in slurry solids concentration. This was the result of the increase in viscosity of the peat slurry as solids content increases, resulting in increased friction losses, and a reduction in the pump capacity.

11. The test results (pressure loss versus flow velocity for lower layer peat) were quite similar to previous information available to Monenco on field tests of Swedish peat slurry, for the same diameter (12 inches) of "plastic" pipeline. They showed that higher solids concentration slurry experienced higher pressure losses than lower solids concentration slurries, for the same pump capacity.

12. A performance comparison was made between the Monenco and USSR TPD-4A peat slurry pumps. It should be noted that the performance characteristic for the Monenco pump at 1000 rpm and 0.03 inches clearance was developed from a pro-rating of test data (lower layer) obtained from the pump on peat slurry at 823 rpm, with 0.5 inches clearance, and on water test data obtained at 1000 rpm and 0.03 inches clearance. The following was observed:

    - at the best efficiency point of 48%, the TPD-4A pump capacity was 3520 USGPM or 800 m^3/hr. The best efficiency point of the Monenco pump was higher (53%) with a higher flow rate (4050 USGPM or 920 m^3/hr). Consequently, the brake horsepower requirement was significantly greater, at a given head, than the TPD-4A pump; and

- o the USSR TPD-4A pump had a larger impeller diameter but operated at lower pump rpm in comparison to the Monenco pump. The effect of a change in impeller diameter is similar to a change in pump speed; both result in a change in the speed of the slurry which leaves the impeller, and therefore the larger diameter impeller of TPD-4A pump compensated somewhat for its low speed when compared with the Monenco pump. The USSR TPD-4A pump was designed for a maximum pump speed of 600 rpm.

13. The field test data (lower layer) showing the relationship between peat slurry viscosity and solids concentration has been added to previous Figure 5-17 which was taken from the earlier Monenco report entitled "Development of Design Parameters for Peat Slurry Pumping and Pipeline Transport." Figure 5-17 shows that the expected optimum peat slurry solids content for an industrial application of the peat slurry pump should be about 6% (by weight) for the type of peat as encountered near Vestal, N.Y. The differences between the average solids concentration obtained during the field tests (3.7% solids) and the optimum industrial solids concentration indicated in Figure 5-17 (6% solids) can be attributed to variations in the in-situ peat characteristics such as peat type, degree of decomposition and ash content, as well as water addition rates.

14. Water for peat slurry preparation was provided by a low pressure pump which supplied the hydromonitors via two high pressure pumps. The maximum capacity of the low pressure pump was 2000 USGPM (7570 l/min), although the level of delivery maintained for the duration of the testing program was between 1300 and 1700 USGPM (4920 and 6440 l/min). A total of 1,702,042 U.S. gal. (6442 m^3) of water was provided by the water supply pumps during operation to prepared 1,746,427 U.S. gal. (6600 m^3) of peat slurry.

15. Performance data on the USSR model GM-2 hydromonitor was compared with data obtained during the test on the Stang equipment. For a 1¾ inch (0.044 m) nozzle using the Stang equipment, nozzle pressures recorded during testing were slightly higher than those recorded for a similar size nozzle mounted on the GM-2. Higher nozzle pressures and greater effective mining ranges of the water jets were attained during the

testing as compared with the ranges reported for the USSR model. The Stang hydromonitor had an effective range of about 30 m compared to 20 m for the USSR hydromonitor.

16. During the pumping demonstration test, peat slurry solids concentrations of between 1 and 7.1% (by weight) were obtained for the lower layer peat. The water addition rate for slurry preparation was calculated based on the desired solids concentration, the moisture content of the layer being mined (80 to 86% moisture) and assumed slurry pump capacities (1500 to 2200 USGPM peat slurry flow rates).

17. Three sets of experiments were conducted to assess the degree of peat maceration occurring during the pumping test, and how it affected the settability and dewaterability of the slurry. These were as follows:

- o particle size distribution;
- o settability; and
- o dewaterability.

a) Particle size distribution tests were performed on in-situ peat, sump slurry and pumped slurry (from the discharge pipe) samples (lower layer peat) to estimate the degree of maceration occurring during the various stages of the pumping and pipelining. Eighteen particle size distribution tests were carried out on these samples. The most obvious indication of maceration is the percentage of the various particles greater than a certain mesh size in the slurry, e.g., those greater than 2 mm before and after pumping. The quantity of particles greater than 2 mm was reduced by 55% by the pump and pipeline when the propeller (stump deflector) was used. A similar percentage reduction was experienced when the propeller was not used, though total particle weights are somewhat higher at both sampling locations. Based on only one solid peat sample, it appeared that hydromonitoring did not contribute significantly to maceration of the peat at a particle level, although it is obviously important in the breakup of large clumps of peat. However, this is

expected to be peculiar to the peat found at the site and requires confirmation with further testing.

b) Both settlability and dewaterability are peat slurry properties which are expected to have a significant effect on wet peat mining operating conditions. Both settlability and dewaterability decreased with an increase in slurry solids content. Settlability was found to decrease rapidly between 2% and 3% total solids. Dewaterability also decreased with increasing solids content, though this relationship appeared to follow a less dramatic curve than settlability, which was exponential. Essentially, a 2% solids slurry settled between six to nine times faster than a 5 to 6% solids slurry, although only two to three times the quantity of peat is mined in the latter. The dewaterability rate decreased by a factor of 2 to 2.5 when the slurry solids content was doubled.

Settling is a cheap water removal process. The major costs associated with it are land area and time requirements. Dewatering is a mechanical process which needs energy input. Very preliminary analysis of settlability data suggested that the degree by which the solids content of the settled peat was increased over the slurry pumped solids content was very small. However, a complete analysis featuring a detailed comparison between the benefits of dewatering versus settlability from both a process and economic standpoint is required.

Section 8
REFERENCES

1. Monenco Ontario Ltd. An Evaluation of Alternative Wet Peat Mining Systems. National Research Council of Canada, NRCC 23016, Ottawa, 1983.

2. Monenco Consultants Ltd. Development of Design Parameters for Peat Slurry Pumping and Pipeline Transport. National Research Council of Canada, NRCC 25033, May 1985.

3. Monenco Consultants Ltd. Design and Construction of Peat Slurry Pump/Macerator. National Research Council of Canada, September 1985.

4. Carlson and Sweatt, Monenco Inc. Statement of New York Peat Resource Inventory. Volume 1. New York State Energy Research and Development Authority, ERDA Report 82-85, July 1982.

5. E.O. Korpijaakko and D.F. Woolnough. Peatland Survey and Inventory. In: Muskey and the Northern Environment in Canada. University of Toronto Press, 1977.

6. Ontario Research Foundation. Characterization of Peat Slurry Properties. Phase 1 Report P-YY3011, 1984.

7. Ontario Research Foundation. Characterization of Peat Slurry Properties. Phase 3 Report P-4510/1, December 1985.

8. John W. Stang Corporation. 4" Stang Intelligiant Manual. California, 1980.

9. Samsonov, N.N. (Editor). Peat Engineers Handbook, pp. 297-392, USSR, 1954.

10. Veller, M.A. et al. Hydropeat Method. -In the Book: Fuel Peat Production. Vol. 2, pp. 55-78, USSR, 1941.

11. Sokolov, B.N. (Editor). Peat Engineers Handbook, pp. 106-121, USSR, 1982.

12. Gorjachkin, V.G. Basic Peat Production Technology, pp. 78-88, USSR, 1953.

13. National Research Council of Canada. Peat Testing Manual. Technical Memorandum No. 125, May 1979.

14. Smoldirev, A.E. and Safonov, U.K. Pipeline Transport of High Solids Content Slurries, pp. 94-95, USSR, 1973.

15. Autio, K. Hydropeat Study. Turveteollisuus No. 5, pp. 126-132, Finland, 1984.

16. Metcalf and Eddy, Inc. Wastewater Engineering: Collection, Treatment, Disposal, pp. 465-469. McGraw-Hill, 1972.

17. A.L. Simon. Practical Hydraulics. S. Wiley & Sons, Inc., New York, 1976.

18. Ideljchik, I.E. Hydraulic Resistances Engineers Handbook, pp. 50-92, USSR, 1975.

19. Petrenko, F.F. Rheological Properties of Highly Concentrated Peat Pulp and the Pressure Drop in Pipelines. -Proceedings of the 2nd International Peat Congress, Volume 1, pp. 519-522, USSR, 1963.

20. Veller, M.A. Hydropeat Technology, USSR, 1948.

21. Williams, E.C. Tests on the Pumping of Raw Peat. -Proceedings of the International Peat Symposium, Ireland, 1954.

22. Gliborskiy, I.N. Hydropeat Equipment. USSR, 1937.

23. Cancross, C.A. Wet Harvesting of Peat. -Proceedings of the Peat Symposium, USA, 1980.

24. Gelfer, B.Y., Mankinen, G.W., Tibbetts, T.E. Wet Peat Mining Systems for Fuel Peat Production. -Proceedings of the 7th International Peat Congress, Vol. 2, pp. 195-207, Ireland, 1984.

APPENDIX A

DETAILED ANALYSIS OF IN-SITU PEAT

TABLE A1 - Preliminary Sample Analyses, Results of the Murphy Site

Sample No.	Moisture Content, %			Ash Content, % (wet basis)			Ash Content, % (dry basis)		
	5g Sample	25g Sample	Avg.	5g Sample	25g Sample	Avg.	5g Samnle	25g Sample	Avg.
1	62.8	60.1	61.5	23.3	27.1	25.2	62.6	67.9	65.3
2	72.3	71.9	72.1	15.9	15.8	15.9	57.4	56.2	56.8
3	77.6	76.7	77.2	11.2	11.7	11.5	50.0	50.2	50.1
4	78.6	78.2	78.4	10.5	10.5	10.5	49.0	48.2	48.6
5	81.9	80.7	81.3	7.3	8.5	7.9	40.3	44.0	42.2
6	83.3	81.9	82.6	6.6	7.4	7.0	39.5	40.9	40.2
7	82.4	82.8	82.6	6.6	6.6	6.6	37.5	38.4	38.0
8	85.0	85.1	85.1	5.7	5.8	5.8	38.0	38.9	38.5
9	87.4	87.6	87.5	4.3	4.4	4.4	34.1	35.5	34.8
10	86.5	87.1	86.8	5.6	5.1	5.4	41.5	39.5	40.5
11	73.4	76.1	74.8	15.0	13.2	14.1	56.4	55.2	55.8
12	88.0	87.6	87.8	4.5	4.7	4.6	37.5	37.9	37.7

Table A-2

Moisture and Ash Determinations for Sites
20E, 35E, 65E, 80E, 95E, 110E, 125E and 140E

Sample No.	% Moisture	% Ash (d.b.)	Sample No.	% Moisture	% Ash (d.b.)
Site 20E					
1	75.9	48.2	2	81.6	41.4
3	79.9	46.8	4	83.5	44.6
5	85.3	34.5	6	83.1	41.8
7	84.2	33.5	8	86.6	29.0
9	85.5	29.8	10	87.0	31.0
11	86.0	35.6	12	86.8	38.8
Site 35E + 20N					
47	84.7	30.0	48	82.3	33.2
49	86.8	16.7	50	85.8	23.8
51	83.2	37.3			
Site 35E + 20S					
52	84.7	47.1	53	86.4	31.4
54	86.0	29.1	55	87.2	34.7
56	84.4	47.1			
Site 65E					
57	82.3	43.6	58	85.1	37.0
59	84.9	25.9	60	86.4	33.7
Site 65E + 10N					
61	83.2	43.8	62	85.5	31.9
63	88.8	12.4	64	90.1	10.9
Site 65E + 20N					
65	85.7	26.6	66	84.4	36.8
67	85.5	34.1	68	86.7	24.5
69	86.1	35.1			
Site 65E + 30N					
1007	82.3	39.0			

Table A-2 (Cont'd)

Moisture and Ash Determinations for Sites
20E, 35E, 65E, 80E, 95E, 110E, 125E and 140E

Sample No.	% Moisture	% Ash (d.b.)	Sample No.	% Moisture	% Ash (d.b.)
Site 65E + 12.5S					
70	82.6	45.4	71	86.6	34.6
72	86.9	33.8	73	88.6	18.2
149	-	22.9	150	-	12.8
Site 65E + 20S					
74	83.8	40.2	75	83.3	38.5
76	84.3	35.4	77	87.9	8.2
78	86.2	29.9			
Site 80E					
35	79.6	46.9	36	85.9	30.8
37	83.6	35.8	38	83.3	34.3
39	85.3	35.4	40	87.1	28.1
41	88.4	20.2	42	90.1	13.8
	87.3	17.5		88.9	19.4
				88.6	19.9
				88.8	19.2
				88.5	22.0
43	88.1	22.5	44	86.8	41.3
45	88.7	33.7	46	86.6	35.6
Site 80E + 10N					
79	84.0	38.6	80	86.9	23.9
81	86.2	31.8	82	87.3	22.0
Site 80E + 20N					
83	86.5	25.8	84	85.1	32.9
85	90.0	7.6	86	87.9	24.3
87	85.1	35.0			
Site 80E + 30N					
1006	86.8	31.2			

Table A-2 (Cont'd)

Moisture and Ash Determinations for Sites
20E, 35E, 65E, 80E, 95E, 110E, 125E and 140E

Sample No.	% Moisture	% Ash (d.b.)	Sample No.	% Moisture	% Ash (d.b.)
Site 80E + 10S					
88	83.4	38.4	89	83.8	39.6
90	85.8	32.8	91	88.6	19.2
151	-	6.7	152	-	8.8
Site 95E					
92	86.6	33.9	93	86.4	26.9
94	88.3	24.0	95	88.7	28.9
Site 95E + 10N					
96	86.4	27.0	97	87.4	15.1
98	90.2	8.2	99	87.6	14.3
Site 95E + 20N					
100	85.6	33.3	101	85.8	27.2
102	87.9	14.8	103	88.2	20.9
104	89.0	22.6			
Site 95E + 28N					
1008	86.0	29.2			
Site 95E + 10S					
105	86.5	30.5	106	86.1	26.5
107	87.5	22.1	108	91.2	10.0
153	-	40.7	154	-	30.1
Site 95E + 20S					
109	85.0	37.4	110	91.3	7.4
111	89.0	16.7	112	86.4	28.4
113	87.7	33.2			

Table A-2 (Cont'd)

Moisture and Ash Determinations for Sites
20E, 35E, 65E, 80E, 95E, 110E, 125E and 140E

Sample No.	% Moisture	% Ash (d.b.)	Sample No.	% Moisture	% Ash (d.b.)
Site 110E					
13	68.6	60.4	14	81.6	40.6
15	84.3	31.7	16	83.6	32.0
17	83.9	32.4	18	84.0	34.2
19	88.0	17.1	20	89.5	9.8
21	85.8	34.9	22	87.4	35.4
23	88.9	31.8			
Site 110E+ 10N					
114	85.7	29.9	115	87.3	23.5
116	86.0	26.7	117	85.8	28.9
Site 110E + 19N					
1009	83.9	31.8			
Site 110E + 10S					
118	85.2	34.5	119	86.0	32.0
120	87.3	28.4	121	89.6	7.2
155	-	42.8	156	-	32.6
Site 110E + 30S					
122	84.7	38.6	123	83.3	39.8
124	86.5	28.4	125	86.5	28.2
126	87.5	25.9			
Site 125E					
127	87.0	27.2	128	85.5	31.7
129	89.6	13.6	130	84.3	42.0
Site 125E + 7.5N					
131	85.6	27.8	132	87.5	18.3
133	85.0	23.9	134	79.8	11.8
1001	85.5	26.3	1002	85.5	31.9
1003	85.4	29.2			

Table A-2 (Cont'd)

Moisture and Ash Determinations for Sites
20E, 35E, 65E, 80E, 95E, 110E, 125E and 140E

Sample No.	% Moisture	% Ash (d.b.)	Sample No.	% Moisture	% Ash (d.b.)
Site 125E + 15N					
135	86.3	27.6	1004	87.4	29.7
1005	84.1	42.7	136	84.1	39.3
137	88.3	18.6	138	88.4	16.3
139	88.6	21.1			
Site 125E + 10S					
140	82.1	27.6	141	85.8	29.3
142	85.5	30.2	143	88.3	17.4
157	-	29.3	158	-	32.6
Site 125E + 20S					
144	84.2	40.9	145	89.3	9.3
146	85.6	26.5	147	85.9	31.7
148	88.6	22.3			
Site 140E					
24	63.2	63.6	25	84.8	29.5
26	83.9	33.3	27	85.4	23.7
28	84.7	36.6	29	84.4	28.0
30	87.5	24.2	31	88.3	17.9
32	89.1	21.1	33	88.4	23.9
34	88.0	37.2			

TABLE A-3 - Preliminary Peat Slurry Viscosity Analyses

	Viscosity (CP) Solids Content (%)				
Samole No.	2%	3%	4%	5%	6%
11	N/A	25	30	50	55
12	30	55	135	N/A	N/A

NOTE: Sample No. 11 was prepared by passing it through a 7 mm grinder. Sample No. 12 was not ground.

TABLE A-4 - Effect of Sample Weight on Final Ash Determination

Sample No.	Sample Wt. (grams)	Drying Time (hours)	Ashing Time (hours)	% Moisture	& Ash (d.b.)
42	57	48	18	89.3	18.1
5	27	48	15	85.2	32.9

TABLE A-5 - The Effect of Ashing Time on Final Ash Determination

Sample No.	% Ash (w.b.) 1 hr @ 600°C	% Ash (w.b.) 18 hrs @ 600°C	% Ash (w.b.) 1.5 hrs @ 900°C	% Ash (d.b.)
13	19.1	19.0	18.9	61.1
16	5.91	5.37	5.29	33.5
19	2.54	2.37	2.34	20.7
21	3.94	3.78	3.75	31.5
23	3.80	3.76	3.76	34.8

TABLE A-6 - Laboratory Analyses of the Murphy Bog Peat Samples

Number of Combined Sample	Number of Individual Sample	Moisture Content %	Ash Content %	Degree of Decomposition %	Viscosity, cPa 7 mm Grinder 15°C Solids Content 3.5%	4.5%	5.5%	pH
'A'	59 64 73 77	88.2	15.98	21.75	75	235	675	5.0
'B'	42 82 91	86.6	18.74	20.5	45	65	180	6.1
'C'	43 151	88.2	15.0	19.63	60	160	490	5.7
'D'	42 43 82 91 151	87.9	23.73	24.0	55	145	465	5.8
'E'	92 97 106 110	86.4	18.15	18.38	45	90	165	5.9
'F'	93 98 107 111	87.0	18.78	16.0	40	85	260	5.7
'G'	94 99 108 112	87.2	18.99	19.75	k50	90	325	5.7

TABLE A-6 - Contd.

Number of Combined Sample	Number of Individual Sample	Moisture Content %	Ash Content %	Degree of Decomposition %	Viscosity, cPa 7 mm Grinder 15°C Solids Content 3.5%	4.5%	5.5%	pH
	92							
	93							
	94							
	97							
	98							
'H'	99	88.0	18.0	20.25	60	200	455	5.9
	106							
	107							
	108							
	110							
	111							
	112							
	20							
'I'	111	87.9	18.49	20.75	50	95	230	5.6
	121							
	125							
	129							
'J'	134	88.0	19.96	21.0	60	155	355	5.8
	143							
	147							
	40							
'K'	80	85.97	27.34	18.75				
	89							
	41							
'L'	81	86.0	31.46	20.25				
	90							
'M'	44	87.66	27.58					
	152							

TABLE A-7 - Basic Composition of Peat

Component	Sample No. 64	Sample No. 80
Carbon, %	47.65	40.62
Hydrogen, %	5.27	4.33
Oxygen, %	35.69	39.83
Nitrogen, %	1.93	1.61
Sulphur, %	0.29	0.28
Calorific Value, Btu/lb (d.w.)	8,210	8,060
Moisture Content, %	90.1	86.4
Ash Content, % (d.w.) @ 850°C	10.9	23.9
Ash Fusion, % (d.w.) @ 1200°C	8.96	10.83

TABLE A-8 - Variation in Conductivity of Peats With Different Ash Contents

Sample No.	Slurry Solids Content (%)	Peat Ash Content (%)	Temperature (°C)	Conductivity (Mho)
39	4.0	35.4	20	440
42	4.0	18.9	20	440

APPENDIX B

SITE LABORATORY MOISTURE AND ASH RESULTS ON PEAT SLURRY SAMPLES

TABLE B-1 - Site Laboratory Moisture and Ash Analyses on Peat Slurry Samples

Date (1985)	Sample #	Moisture Content (%)	Ash Content (%)
August			
19	1	1.0	49.6
	4	4.0	43.0
	7	4.5	52.8
20	1	5.0	52.8
	2	6.5	44.6
	3	10.5	40.9
	4	10.0	16.7
	5	12.0	12.2
21	1 (solid)	14.0	32.0
	1	5.0	65.6
	3	8.0	46.4
	4	9.0	62.0
22	1	6.0	30.9
	2	5.5	40.0
	3	5.0	34.0
	4	6.0	28.0
	5	6.0	31.0
23	1	4.5	13.5
	2	4.5	25.1
	3	4.5	19.6
	4	5.0	22.2
	5	4.0	18.5
	6	3.5	24.9
	7	3.0	22.1
24	1	1.0	14.6
	2	1.0	14.0
	3	2.0	14.9
	4	3.5	13.8
	5	4.0	10.2
	6	3.5	17.4
26	1	4.0	22.9
	2	6.0	19.07
	3	6.0	21.9
	4	5.0	17.6
	5	5.0	16.8
	6	6.5	14.9
	10	4.5	12.5

APPENDIX C

DATA ON MONITORING AND ANALYTICAL EQUIPMENT USED AT TEST SITE

Process Equipment

1. Flow Measurement

(a) Signet Magnetic Flowmeter

Type	- MK-565
Range	- 0 - 5000 U.S. gal/min
Material	- Plastic
Installation	- Simple insertion type, held in place by saddle which is strapped on

(b) Unimeter Ultrasonic Doppler Flowmeter

Type	- Model P3
Range	- 0 - 20 ft/sec

Digital readout is "hand held", while sensor is taped and fixed to outside of pipe. Silicone grease or similar material is used to fix sensor.

2. Pressure Measurement

(a) Pressure Gauge

Type	- 1981 Z
Range	- 0 - 100 psi (3), 0 - 60 psi (1)
Material	- Brass

(b) Pressure Gauge Protectors

Type	- 8G
Range	- Same as above
Material	- Stainless Steel
Size	- 1" NPT inlet, 1/2" NPT outlet

3. Temperature Measurement

Tel-Tru Threaded Thermometer

Range	- 0 - 100°C
Type	- GT-500 R
Size	- Connection 1/2" NPT

4. RPM Measurement

Tachtrol Tachometer

Type	- Tachtrol 2, 120 V and 12V D.C. Digital R/O field with pick-up and mount

5. Power Measurement

1 KYWP, 2 Element Transformer type meter with appropriate current and potential transformers

Analytical Equipment

(1) Phaus Moisture Balance: 375 watts; 10 gram scale; for moisture determination

(2) Lindberg Furnace: Range 0 - 1000°C; 250 volts, 30 amps; for ash determination

(3) Thomas-Stormer Viscometer for viscosity

APPENDIX D

PUMP TEST DATA SHEETS

FIELD DATA SHEET

Test #: Trial Pump Setting: 1" Cl Time: Date: 15/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	7.0		
Slurry Velocity	Feet/sec			
Pressure 1	psig	12.0		
2	psig	8.75		
3	psig			
4	psig			
5	psig	1.5		
6	psig	1.0		
Power Demand	kw			
Total Power	kwh	168 (Fin)		
Flow Rate				
High Pressure Pump #1	L/sec	60		
High Pressure Pump #2	L/sec	42		
Discharge Pressure				
High Pressure Pump #1	psig	160		
High Pressure Pump #2	psig	150		
Discharge Pressure				
Hydromonitor #1	psig	155		
Hydromonitor #2	psig	145		
Nozzle Size				
Hydromonitor #1	Inches	1.75		
Hydromonitor #2	Inches	1.5		
Duration of Test	Minutes	77		
Temperature	^{o}C	24		
Pump Speed	rpm	761		
No. of Samples		5		

FIELD DATA SHEET

Test #: Trial Pump Setting: 1" Cl Time: Date: 16/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	7.0		
Slurry Velocity	Feet/sec			
Pressure 1	psig	13.0		
2	psig	10.0		
3	psig			
4	psig			
5	psig	1.5		
6	psig	1.0		
Power Demand	kw			
Total Power	kwh	194 (Fin)		
Flow Rate				
High Pressure Pump #1	L/sec	50		
High Pressure Pump #2	L/sec	52		
Discharge Pressure				
High Pressure Pump #1	psig	160		
High Pressure Pump #2	psig	135		
Discharge Pressure				
Hydromonitor #1	psig	160		
Hydromonitor #2	psig	118		
Nozzle Size				
Hydromonitor #1	Inches	1.5		
Hydromonitor #2	Inches	1.75		
Duration of Test	Minutes	24		
Temperature	^{o}C	20		
Pump Speed	rpm	735		
No. of Samples		1		

FIELD DATA SHEET

Test #: Trial Pump Setting: 1" Cl Time: Date: 17/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	7.0		
Slurry Velocity	Feet/sec			
Pressure 1	psig	9.25		
2	psig	7.75		
3	psig			
4	psig			
5	psig	1.0		
6	psig	1.0		
Power Demand	kw			
Total Power	kwh	349 (Fin)		
Flow Rate				
High Pressure Pump #1	L/sec	38		
High Pressure Pump #2	L/sec	47		
Discharge Pressure				
High Pressure Pump #1	psig	105		
High Pressure Pump #2	psig	107		
Discharge Pressure				
Hydromonitor #1	psig	96		
Hydromonitor #2	psig	105		
Nozzle Size				
Hydromonitor #1	Inches	1.5		
Hydromonitor #2	Inches	1.75		
Duration of Test	Minutes	164		
Temperature	^{o}C	21		
Pump Speed	rpm	735		
No. of Samples		5		

FIELD DATA SHEET

Test #: Trial Pump Setting: 1" Cl Time: Date: 19/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	7.0	7.0	7.0
Slurry Velocity	Feet/sec			
Pressure 1	psig	9.5	9.5	9.75
2	psig	8.0	7.75	8.25
3	psig			
4	psig			
5	psig	1.0	1.0	1.0
6	psig	1.0	1.0	1.0
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	41	41	69
High Pressure Pump #2	L/sec	24	24	28
Discharge Pressure				
High Pressure Pump #1	psig	160	160	210
High Pressure Pump #2	psig	30	30	40
Discharge Pressure				
Hydromonitor #1	psig	155	155	182
Hydromonitor #2	psig	18	18	35
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	21	35	36
Temperature	^{o}C	21	21	21
Pump Speed	rpm	735	738	735
No. of Samples		2	1	2

FIELD DATA SHEET

Test #: Trial Pump Setting: 1" Cl Time: 1.46 μm Date: 19/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	7.0	7.0	
Slurry Velocity	Feet/sec			
Pressure 1	psig	9.0	9.5	
2	psig	7.5	8.0	
3	psig			
4	psig			
5	psig	< 1.0	1.5	
6	psig	< 1.0	1.0	
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	69	69	
High Pressure Pump #2	L/sec	28	28	
Discharge Pressure				
High Pressure Pump #1	psig	210	210	
High Pressure Pump #2	psig	40	40	
Discharge Pressure				
Hydromonitor #1	psig	182	182	
Hydromonitor #2	psig	35	35	
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	
Hydromonitor #2	Inches	1.5	1.5	
Duration of Test	Minutes	127	17	
Temperature	^{o}C	21	21	
Pump Speed	rpm	767	820	
No. of Samples		2	1	

FIELD DATA SHEET

Test #: Trial Pump Setting: 1" Cl Time: Date: 20/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	7.0	7.0	7.0
Slurry Velocity	Feet/sec			
Pressure 1	psig	12.5	11.5	11.5
2	psig	8.75	9.5	9.5
3	psig			
4	psig			
5	psig	1.25	< 1.0	< 1.0
6	psig	1.0	< 1.0	< 1.0
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	69	0	67
High Pressure Pump #2	L/sec	0	54	0
Discharge Pressure				
High Pressure Pump #1	psig	210	0	200
High Pressure Pump #2	psig	0	145	0
Discharge Pressure				
Hydromonitor #1	psig	185	0	180
Hydromonitor #2	psig	0	135	0
Nozzle Size				
Hydromonitor #1	Inches	1.75		1.75
Hydromonitor #2	Inches		1.75	
Duration of Test	Minutes	110	18	59
Temperature	^{o}C	21	21	21
Pump Speed	rpm	820	825	825
No. of Samples		2	2	2

FIELD DATA SHEET

Test #: Trial Pump Setting: 1" Cl Time: Date: 21/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	7.0	7.0	
Slurry Velocity	Feet/sec			
Pressure 1	psig	11.5	11.0	
2	psig	8.5	8.5	
3	psig			
4	psig			
5	psig	1.0	1.0	
6	psig	1.0	1.0	
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	65	68	
High Pressure Pump #2	L/sec	25	56	
Discharge Pressure				
High Pressure Pump #1	psig	190	200	
High Pressure Pump #2	psig	23	160	
Discharge Pressure				
Hydromonitor #1	psig	165	190	
Hydromonitor #2	psig	20	145	
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	
Hydromonitor #2	Inches	1.75	1.75	
Duration of Test	Minutes	72	156	
Temperature	^{o}C	21	21	
Pump Speed	rpm	833	833	
No. of Samples		4	4	

FIELD DATA SHEET

Test #: Trial Pump Setting: 1° Cl Time: Date: 22/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	12.0	12.0	12.0
Slurry Velocity	Feet/sec			
Pressure 1	psig	15.0	12.0	10.0
2	psig	8.0	8.25	8.25
3	psig			
4	psig			
5	psig	1.0	1.0	1.0
6	psig	1.0	1.0	1.0
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	54	55	55
High Pressure Pump #2	L/sec	21	27	27
Discharge Pressure				
High Pressure Pump #1	psig	130	128	128
High Pressure Pump #2	psig	18	32	32
Discharge Pressure				
Hydromonitor #1	psig	112	110	110
Hydromonitor #2	psig	15	30	30
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.75	1.75	1.75
Duration of Test	Minutes	20	20	21
Temperature	^{o}C	18	18	18
Pump Speed	rpm	785	785	785
No. of Samples		2	2	2

FIELD DATA SHEET

Test #: Trial Pump Setting: 1" Cl Time: Date: 22/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	12.0		
Slurry Velocity	Feet/sec			
Pressure 1	psig	10.5		
2	psig	8.25		
3	psig			
4	psig			
5	psig	1.0		
6	psig	1.0		
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	50		
High Pressure Pump #2	L/sec	0		
Discharge Pressure				
High Pressure Pump #1	psig	100		
High Pressure Pump #2	psig	0		
Discharge Pressure				
Hydromonitor #1	psig	95		
Hydromonitor #2	psig	0		
Nozzle Size				
Hydromonitor #1	Inches	1.75		
Hydromonitor #2	Inches	1.75		
Duration of Test	Minutes	12		
Temperature	^{o}C	18		
Pump Speed	rpm	785		
No. of Samples				

FIELD DATA SHEET

Test #: 1 Pump Setting: 1/2" Cl Time: 10.48 am Date: 23/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	9.0	9.0	9.0
Slurry Velocity	Feet/sec	6.3	5.6	5.15
Pressure 1	psig	14.5	17.5	19.5
2	psig	10.0	9.75	8.5
3	psig			
4	psig			
5	psig	1.5	1.5	1.5
6	psig	1.0	1.0	1.0
Power Demand	kw			
Total Power	kwh	1294 (st)		
Flow Rate				
High Pressure Pump #1	L/sec	50	50	50
High Pressure Pump #2	L/sec	28	50	50
Discharge Pressure				
High Pressure Pump #1	psig	110	110	110
High Pressure Pump #2	psig	30	150	150
Discharge Pressure				
Hydromonitor #1	psig	96	96	96
Hydromonitor #2	psig	30	120	120
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.75	1.75	1.75
Duration of Test	Minutes	14	11	13
Temperature	^{o}C	17	17	17
Pump Speed	rpm	830	830	830
No. of Samples		3	6	3

FIELD DATA SHEET

Test #: 2 Pump Setting: 1/2" Cl Time: 11.36 am Date: 23/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	5.75	5.0	6.25
Pressure 1	psig	16.75	20.0	13.5
2	psig	9.25	8.5	10.0
3	psig			
4	psig			
5	psig	1.5	1.5	1.5
6	psig	1.0	1.0	1.0
Power Demand	kw			
Total Power	kwh			1408 (Fin)
Flow Rate				
High Pressure Pump #1	L/sec	50	50	50
High Pressure Pump #2	L/sec	55	55	55
Discharge Pressure				
High Pressure Pump #1	psig	110	100	100
High Pressure Pump #2	psig	150	150	150
Discharge Pressure				
Hydromonitor #1	psig	96	92	92
Hydromonitor #2	psig	120	135	135
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.75	1.75	1.75
Duration of Test	Minutes	11	10	15
Temperature	^{o}C	17	17	17
Pump Speed	rpm	830	830	830
No. of Samples		6	6	6

FIELD DATA SHEET

Test #: 3 Pump Setting: 1/2" Cl Time: 9.49 am Date: 24/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	5.8	5.7	4.85
Pressure 1	psig	12.5	17.0	20.0
2	psig	9.25	9.0	8.5
3	psig			
4	psig			
5	psig	1.5	1.5	1.5
6	psig	1.0	1.0	1.0
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	43	43	43
High Pressure Pump #2	L/sec	43	43	43
Discharge Pressure				
High Pressure Pump #1	psig	70	70	70
High Pressure Pump #2	psig	100	100	100
Discharge Pressure				
Hydromonitor #1	psig	60	60	60
Hydromonitor #2	psig	90	95	95
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.75	1.75	1.75
Duration of Test	Minutes	10	7	10
Temperature	^{o}C	18	18	18
Pump Speed	rpm	832	833	785
No. of Samples		3	3	3

FIELD DATA SHEET

Test #: 4 Pump Setting: 1/2" Cl Time: 10.25 am Date: 24/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	4.7	5.6	5.75
Pressure 1	psig	19.5	16.5	13.5
2	psig	8.25	8.75	9.75
3	psig			
4	psig			
5	psig	1.5	1.5	1.5
6	psig	1.0	1.0	1.0
Power Demand	kw			
Total Power	kwh			1494 (Fin)
Flow Rate				
High Pressure Pump #1	L/sec	42	42	42
High Pressure Pump #2	L/sec	48	53	53
Discharge Pressure				
High Pressure Pump #1	psig	70	70	70
High Pressure Pump #2	psig	120	150	150
Discharge Pressure				
Hydromonitor #1	psig	65	65	65
Hydromonitor #2	psig	115	135	135
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.75	1.75	1.75
Duration of Test	Minutes	9	6	4
Temperature	^{o}C	18	18	18
Pump Speed	rpm	832	833	833
No. of Samples		3	6	3

FIELD DATA SHEET

Test #: 5 Pump Setting: 1/2" Cl Time: 8.55 am Date: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	6.9	5.75	4.95
Pressure 1	psig	13.5	17.0	20.0
2	psig	10.0	9.25	8.25
3	psig	6.25	5.75	5.25
4	psig	6.75	6.0	5.5
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh	1494 (St)		
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	12	7	10
Temperature	^{o}C	19	19	19
Pump Speed	rpm	825	823	826
No. of Samples		3	3	3

FIELD DATA SHEET

Test #: 6 Pump Setting: 1/2" Cl Time: 9.24 am Date: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	4.6	5.3	6.0
Pressure 1	psig	20.0	17.0	14.0
2	psig	8.5	9.25	10.25
3	psig	5.25	6.0	6.75
4	psig	5.75	6.5	7.0
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	7	7	7
Temperature	^{o}C	19	19	19
Pump Speed	rpm	825	825	825
No. of Samples		3	3	3

FIELD DATA SHEET

Test #: 7 Pump Setting: 1/2" Cl Time: 9.45 am Date: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	5.8	5.55	5.0
Pressure 1	psig	14.5	17.0	20.0
2	psig	10.25	9.5	8.25
3	psig	6.5	6.0	5.25
4	psig	7.0	6.25	5.75
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	6	7	7
Temperature	^{o}C	19	19	19
Pump Speed	rpm	825	825	825
No. of Samples		3	3	6

FIELD DATA SHEET

Test #: 8 Pump Setting: 1/2" Cl Time: 10.05 am Date: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	4.9	5.55	5.75
Pressure 1	psig	20.0	16.75	13.0
2	psig	7.25	9.0	9.75
3	psig	5.25	5.75	6.25
4	psig	5.75	6.25	6.75
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	8	6	9
Temperature	^{o}C	19	19	19
Pump Speed	rpm	825	825	825
No. of Samples		3	3	3

FIELD DATA SHEET

Test #: 9 Pump Setting: 1/2" C1 Time: 10.28 am Date: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	5.7	5.55	4.6
Pressure 1	psig	14.0	16.5	20.0
2	psig	9.75	9.25	8.5
3	psig	6.25	5.75	5.5
4	psig	6.75	6.25	6.0
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh			
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	7	6	7
Temperature	^{o}C	19	19	19
Pump Speed	rpm	825	825	825
No. of Samples		3	3	3

FIELD DATA SHEET

Test #: 10 Pump Setting: 1/2" Cl Time: 10.48 am Date: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	4.65	5.2	6.0
Pressure 1	psig	20.0	16.75	13.5
2	psig	8.25	9.0	10.0
3	psig	5.25	5.75	6.5
4	psig	4.75	6.25	6.75
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh			1670 (Fin)
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	6	6	6
Temperature	^{o}C	19	19	19
Pump Speed	rpm	825	825	825
No. of Samples		3	3	3

FIELD DATA SHEET

Test #: 11 Pump Setting: 1/2" Cl No Prop Time: 3.41 pm Date: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	6.3	5.7	4.9
Pressure 1	psig	13.5	16.0	20.0
2	psig	10.0	9.25	8.25
3	psig	6.5	6.0	5.25
4	psig	7.0	6.5	5.75
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh	1682 (Fin)	1693 (Fin)	1699 (Fin)
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	6	7	6
Temperature	^{o}C	19	19	19
Pump Speed	rpm	795	800	800
No. of Samples		3	3	3

FIELD DATA SHEET

Test #: 12 **Pump Setting**: 1/2" Cl No Prop **Time**: 4.00 pm **Date**: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	5.0	5.45	5.7
Pressure 1	psig	20.0	16.5	13.5
2	psig	8.25	9.25	10.0
3	psig	5.25	5.75	6.75
4	psig	5.75	6.0	7.0
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh		1712 (Fin)	1722 (Fin)
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	7	8	3
Temperature	^{o}C	19	19	19
Pump Speed	rpm	808	808	808
No. of Samples		3	3	2

FIELD DATA SHEET

Test #: 13 Pump Setting: 1/2" Cl No Prop Time: 4.18 pm Date: 26/08/85

Parameters	Units	Run #1	Run #2	Run #3
Pump Depth	Feet	11.0	11.0	11.0
Slurry Velocity	Feet/sec	5.2	5.55	4.65
Pressure 1	psig	13.5	16.5	20.0
2	psig	10.0	9.5	8.25
3	psig	6.75	5.75	5.25
4	psig	7.0	6.25	5.75
5	psig			
6	psig			
Power Demand	kw			
Total Power	kwh			1735 (Fin)
Flow Rate				
High Pressure Pump #1	L/sec	63	63	63
High Pressure Pump #2	L/sec	36	36	36
Discharge Pressure				
High Pressure Pump #1	psig	170	170	170
High Pressure Pump #2	psig	115	115	115
Discharge Pressure				
Hydromonitor #1	psig	150	150	150
Hydromonitor #2	psig	110	110	110
Nozzle Size				
Hydromonitor #1	Inches	1.75	1.75	1.75
Hydromonitor #2	Inches	1.5	1.5	1.5
Duration of Test	Minutes	3	3	4
Temperature	^{o}C	19	18	19
Pump Speed	rpm	808	808	808
No. of Samples		2	2	1

APPENDIX E

CALCULATION SHEETS - PUMPING AND MINING PARAMETERS

TABLE E-1 - New York Peat Slurry Pumping Demonstration Project : Field Data Collected by ORF

					WATER SUPPLY SYSTEM				PEAT SLURRY PUMP / PIPELINE SYSTEM										
									PEAT SLURRY							PEAT DEPOSIT			
DATE	TEST NUMBER	RUN NUMBER	PEAT DEPTH INTERVAL ft (m)	RUN TIME(MIN)	PUMP rpm	FLOW USGPM	TOTAL FLOW USGAL	TOTAL FLOW M3	FLOWRATE (USGPM)	TOTAL FLOW USGAL	TOTAL FLOW M3	SOLIDS CONTENT (%)	ASH CONTENT (%)	VISCOSITY cp	TEMP C	MOISTURE CONTENT (%)	ASH CONTENT (%)	DEGREE OF DECOMP'N (%)
RATED SPEED 800 rpm, 1 inch CLR, Top layer peat																			
1985-08-15	TRI-1	1	0-2.6 (0-0.8)	77	761	1617	124509	471.3	1760	135520	512.9	9.00	49.0	100	24	79.6	47.00	----
1985-08-16	TRI-2	1	0-2.6 (0-0.8)	24	783	1617	38808	146.9	1500	36000	136.3	7.00	48.0	170	20	82.8	47.00	----
1985-08-17	TRI-3	1	0-3.9 (0-1.2)	164	735	1339	219596	831.2	1220	200080	757.3	5.00	37.0	40	21	83.3	36.90	----
1985-08-19	TRI-4	1	0-3.9	21	738	1030	21630	81.9	1375	33075	125.2	1.00	49.0	15	21	83.6	36.90	----
		4	(0-1.2)	127	767	1537	195199	738.8	1245	158115	598.5	4.00	43.0	30	23	83.6	39.00	----
		5		17	820	0	0	0.0	1195	20315	76.9	5.00	53.0	40	23	83.6	39.00	----
1985-08-20	TRI-5	1	0-3.9	110	820	1094	120340	455.5	1535	168850	639.1	7.00	46.0	70	21	84.5	39.00	----
		3	(0-1.2)	59	825	1062	62658	237.2	1150	67850	256.8	10.00	47.0	70	21	84.5	39.00	----
1985-08-21	TRI-6	1	2.6-5.2	75	833	1427	107025	405.1	1630	122250	462.7	5.00	46.0		21	84.5	39.00	----
		2	(0.8-1.6)	136	833	1965	306340	1160.3	1230	191880	726.3	8.00	46.0		21	84.5	39.00	----
1985-08-22	TRI-7	4	3.9-6.6 (1.2-2.0)	12	785	793	9516	36.0	1040	12480	47.2	6.00	35.0		18	85.0	39.00	----
RATED SPEED 800rpm, 0.5 inch CLR, Lower layer peat																			
1985-08-23		N.P.	6.6-11.8	15	---	729	10935	41.4	----	----	----	----	----	----	----	----	----	----	----
	1	1	(2.0-3.6)	14	830	1236	17304	65.5	2220	31080	117.6	5.0	38.9	46	17	85.4	27.10	18.8
		2		21	830	1586	33306	126.1	1974	41454	156.9	4.7	38.3	46	17	85.4	27.10	18.8
		3		13	830	1596	20748	78.5	1815	23595	89.3	2.9	39.6	46	17	85.4	27.10	18.8
	2	1		11	830	1586	17446	66.0	2027	22297	84.4	2.6	36.1	30	17	85.4	27.10	18.8
		2		10	830	1665	16650	63.0	1763	17630	66.7	2.8	35.1	30	17	85.4	27.10	18.8
		3		15	830	1665	24975	94.5	2203	33045	125.1	3.1	40.2	30	17	85.4	27.10	18.8
1985-08-24		N.P.	6.6-11.8	15	---	713	10695	40.5	----	----	----	----	----	----	----	----	----	----	----
	3	1	(2.0-3.6)	10	785	1363	13630	51.6	2080	20800	78.7	1.0	34.8	30	18	85.4	22.90	20.4
		2		7	785	1363	9541	36.1	2009	14063	53.2	2.8	28.7	30	18	85.4	22.90	20.4
		3		10	833	1364	13640	51.6	1710	17100	64.7	2.6	25.5	30	18	85.4	22.90	20.4
	4	1		9	832	1427	12843	48.6	1657	14913	56.4	2.8	25.7	30	18	85.4	22.90	20.4
		2		6	833	1506	9036	34.2	1974	11844	44.8	2.1	22.8	30	18	85.4	22.90	20.4
		3		4	833	1506	6024	22.8	2027	8108	30.7	3.2	28.1	30	18	86.6	22.90	20.4
1985-08-26	5	1	6.6-11.8	12	825	1569	18828	71.3	2432	29184	110.5	0.8	38.3	32	19	86.6	22.90	20.4
		2	(2.0-3.6)	7	825	1570	10990	41.6	2027	14189	53.7	2.6	36.8	32	19	86.6	22.90	20.4
		3		10	825	1570	15700	59.4	1745	17450	66.0	3.8	35.6	32	19	86.6	22.90	20.4
	6	1		7	825	1570	10990	41.6	1622	11354	43.0	7.1	33.8	230	19	86.6	22.90	20.4
		2		7	825	1570	10990	41.6	1868	13076	49.5	5.9	33.0	230	19	86.6	22.90	20.4
		3		7	825	1570	10990	41.6	2115	14805	56.0	5.9	32.5	230	19	86.6	22.90	21.0
	7	1		6	825	1570	9420	35.7	2045	12270	46.4	5.8	31.2	55	19	86.6	22.90	21.0
		2		7	825	1570	10990	41.6	1956	13692	51.8	4.7	31.7	55	19	86.6	22.90	21.0
		3		7	825	1570	10990	41.6	2027	14189	53.7	3.2	30.9	55	19	86.6	22.90	21.0
	8	1		8	825	1570	12560	47.5	1727	13816	52.3	5.1	31.5	77	19	86.6	22.90	21.0
		2		6	825	1570	9420	35.7	1956	11736	44.4	4.3	27.8	77	19	86.6	22.90	21.0
		3		9	825	1570	14130	53.5	2027	18243	69.0	4.0	24.8	7/	19	86.6	22.90	21.0
	9	1		7	825	1570	10990	41.6	2009	14063	53.2	5.0	32.1	53	19	87.7	23.90	21.0
		2		6	825	1570	9420	35.7	1956	11736	44.4	3.8	30.5	53	19	87.7	23.90	21.0
		3		7	825	1570	10990	41.6	1622	11354	43.0	4.5	34.9	53	19	87.7	23.90	21.0
	10	1		6	825	1570	9420	35.7	1639	9834	37.2	4.5	35.7	60	19	87.7	23.90	21.0
		2		6	825	1570	9420	35.7	1833	11998	41.6	5.8	32.9	60	19	87.7	23.90	21.0
		3		6	825	1570	9420	35.7	2115	12690	48.0	5.0	32.9	60	19	87.7	23.90	21.0
	11	1	w/o propel	6	795	1570	9420	35.7	2220	13320	50.4	2.1	33.7	45	19	87.7	23.90	21.0
		2	"	7	800	1570	10990	41.6	2009	14063	53.2	3.8	33.3	45	19	87.7	23.90	21.0
		3	"	6	800	1570	9420	35.7	1727	10362	39.2	3.1	32.5	45	19	87.7	23.90	21.0
	12	1	"	7	800	1570	10990	41.6	1763	12341	46.7	4.3	31.4	49	19	87.7	23.90	21.0
		2	"	8	800	1570	12560	47.5	1921	15360	58.2	4.5	33.2	49	19	87.7	23.90	24.0
		3	"	3	800	1570	4710	17.8	2009	6027	22.8	4.1	33.4	49	19	87.7	23.90	24.0
	13	1	"	3	800	1570	4710	17.8	1833	5499	20.8	5.4	33.8	185	19	87.7	23.90	24.0
		2	"	3	800	1570	4710	17.8	1956	5868	22.2	5.4	33.8	185	19	87.7	23.90	24.0
		3	"	6	800	1570	6280	23.8	1639	6556	24.8	5.4	33.8	185	19	87.7	23.90	24.0

TABLE E-2 - New York Peat Slurry Pumping Demonstration Project :
Calculated Test Results on Peat Slurry

DATE	TEST NUMBER	RUN NUMBER	TOTAL FLOW USGAL (ORF Data)	TOTAL FLOW M3	VELOCITY ft/sec	VELOCITY m/sec	SOLIDS CONTENT (%) (ORF Data)	TOTAL HEAD ft	TOTAL HEAD m	POWER DEMAND kH (ORF Data)	BRAKE HORSEPWR HP	HYDR HORSEPWR HP	PUMP EFF	EXTRACTED M3	EXTRACTED M3/HR	TOT PEAT PUMPED TONNE 0% MOIST.	PUMP CAPACITY TONNE/HR 0% MOIST.	WATER ADDITION COEFF'T
RATED SPEED	800rpm, 0.5 inch CLR, Lower layer peat																	
1985-08-23	N.P.	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	1	1	31080	117.6	6.30	1.92	5.0	45.3	15.8	82	98.9	27.6	27.9	40.3	172.7	5.88	25.21	1.92
		2	41454	156.9	5.60	1.71	4.7	54.1	16.5	82	98.9	27.0	27.2	58.5	144.3	7.37	21.07	2.11
		3	23395	89.3	5.15	1.57	2.9	58.4	17.8	82	98.9	26.8	27.0	17.7	81.9	2.59	11.95	4.83
	2	1	22297	84.4	5.75	1.75	2.6	54.9	16.7	82	98.9	28.1	28.4	15.8	82.0	2.19	11.97	4.62
		2	17638	66.7	5.00	1.52	2.0	60.8	18.5	82	98.9	27.1	27.4	9.1	54.8	1.33	8.01	6.30
		3	33045	125.1	6.25	1.90	3.1	47.7	14.5	82	98.9	26.5	26.8	26.6	106.2	3.88	15.51	3.71
1985-08-24		---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	3	1	20800	78.7	5.90	1.80	1.0	45.1	13.7	84	101.3	23.7	23.4	5.4	32.4	0.79	4.72	13.60
		2	14063	53.2	5.70	1.74	2.8	54.8	16.7	84	101.3	27.8	27.4	10.2	87.5	1.49	12.77	4.21
		3	17100	64.7	4.85	1.48	2.6	66.6	18.5	84	101.3	26.2	25.8	11.5	69.2	1.68	10.10	4.62
	4	1	14913	56.4	4.70	1.43	2.8	59.4	18.1	84	101.3	24.8	24.5	10.8	72.2	1.58	10.54	4.21
		2	11844	44.8	5.60	1.71	2.1	58.7	17.9	84	101.3	29.2	28.9	6.4	64.5	0.94	9.41	5.95
		3	8108	30.7	5.75	1.75	3.2	46.9	14.3	84	101.3	24.0	23.7	6.7	100.9	0.98	14.73	3.56
1985-08-26	5	1	29184	110.5	6.90	2.10	0.8	48.9	14.9	81	97.7	30.0	30.7	6.6	33.0	0.88	4.42	15.75
		2	14189	53.7	5.75	1.75	2.6	55.0	16.8	81	97.7	28.1	28.8	10.4	89.3	1.40	11.97	4.15
		3	17450	66.0	4.95	1.51	3.0	60.8	18.5	81	97.7	26.8	27.4	10.7	112.4	2.51	15.06	2.53
	6	1	11354	43.0	4.60	1.40	7.1	62.4	19.0	81	97.7	25.5	26.1	22.8	195.2	3.05	26.15	0.89
		2	13076	49.5	5.30	1.62	5.9	56.9	17.3	81	97.7	26.8	27.5	21.8	186.8	2.92	25.03	1.27
		3	14865	56.0	6.00	1.83	5.9	51.5	15.7	81	97.7	27.5	28.1	24.7	211.5	3.31	28.34	1.27
	7	1	12270	46.4	5.80	1.77	5.8	50.7	15.5	81	97.7	26.2	26.8	20.1	201.0	2.69	26.94	1.31
		2	13692	51.8	5.55	1.69	4.7	55.3	16.9	81	97.7	27.3	27.9	18.2	155.8	2.44	20.88	1.85
		3	14189	53.7	5.75	1.75	3.2	62.6	19.1	81	97.7	32.0	32.8	12.8	109.9	1.72	14.73	3.19
	8	1	13816	52.3	4.90	1.49	5.1	61.6	18.8	81	97.7	26.9	27.5	19.9	149.3	2.67	20.00	1.63
		2	11736	44.4	5.55	1.69	4.3	55.7	17.0	81	97.7	27.5	28.1	14.3	142.5	1.91	19.10	2.12
		3	10243	69.0	5.75	1.75	4.0	47.1	14.4	81	97.7	24.1	24.7	20.6	137.4	2.76	18.41	2.35
	9	1	14063	53.2	5.70	1.74	5.0	48.5	14.8	81	97.7	24.6	25.2	21.6	185.5	2.66	22.81	1.46
		2	11736	44.4	5.55	1.69	3.8	54.2	16.5	81	97.7	26.8	27.4	13.7	137.2	1.69	16.88	2.24
		3	11354	43.0	4.60	1.40	4.5	60.7	18.5	81	97.7	24.9	25.4	15.7	134.8	1.93	16.58	1.73
	10	1	9834	37.2	4.65	1.42	4.5	60.9	18.6	81	97.7	25.2	25.8	13.6	136.2	1.67	16.75	1.73
		2	10998	41.6	5.20	1.59	5.0	54.8	16.7	81	97.7	25.4	25.9	16.9	169.2	2.08	20.81	1.46
		3	12690	48.0	6.00	1.83	5.0	48.2	14.7	81	97.7	25.7	26.3	19.5	195.3	2.40	24.02	1.46
	11	1	13320	50.4	6.30	1.92	2.1	48.3	14.7	120	144.8	27.1	18.7	8.6	86.1	1.06	10.59	4.86
		2	14063	53.2	5.70	1.74	3.8	53.3	16.2	78	94.1	27.0	28.7	16.4	141.8	2.02	17.34	2.24
		3	10362	39.2	4.90	1.49	3.1	61.0	18.6	78	94.1	26.6	28.3	9.9	98.8	1.22	12.16	2.97
	12	1	12341	46.7	5.00	1.52	4.2	61.3	18.7	77	92.9	27.3	29.4	16.3	140.0	2.01	17.22	1.86
		2	15368	58.2	5.45	1.66	4.5	54.8	16.5	77	92.9	26.2	28.2	21.3	159.6	2.62	19.63	1.73
		3	6027	22.8	5.70	1.74	4.1	47.4	14.4	77	92.9	24.8	25.9	7.6	152.1	0.94	18.71	2.00
	13	1	5499	20.8	5.20	1.59	5.4	48.9	14.7	78	70.2	16.7	23.7	9.1	182.8	1.12	22.48	1.28
		2	5868	22.2	5.55	1.69	5.4	56.1	17.1	78	70.2	20.7	29.4	9.8	195.0	1.20	23.99	1.28
		3	6556	24.8	4.65	1.42	5.4	62.2	19.0	78	70.2	19.2	27.3	10.9	163.4	1.34	20.10	1.28

APPENDIX F

PEAT SLURRY PUMP ESTIMATED PERFORMANCE DATA

PUMP PERFORMANCE ANALYSIS

1. The water test performance characteristics for the pump was given by the manufacturers for the following operating conditions:

   - 0.03 inch clearance at 1000 rpm
   - 1 inch clearance at 1000 rpm
   - 1 inch clearance at 800 rpm

   From these characteristics, the performance of the pump was interpolated for 0.5 inch clearance at 800 rpm for water. From this the performance characteristics at 800 rpm was pro-rated and this was used as the estimated base operating curve of the test pump for water (Figure 5-7, 5-8 and 5-9).

   From the field data, a regression analysis was carried out. First, all field data was analysed, without any consideration for solids content. Considering that the pump flow rate varied in a rather limited range (1600-2200 USGPM), it was assumed that pump head was linearly related to the flow rate within the test range. The following relationship was obtained (see Figure 5-9):

   $$H = 97.8 - 0.02234\ Q \qquad (1)$$

   where "H" is pump head, ft
   "Q" is flow rate, USGPM

   A second regression analysis was carried out, this time including the effect of the solids concentration. The following relationship was obtained (Figure 5-8):

   $$H = 100.7 - 0.023\ Q - 0.369\ S \qquad (2)$$

   where "H" is pump head, ft
   "Q" is flow rate, USGPM
   "S" is solids concentration, %

In both of the regression equations, the scotter of data was within an acceptable range.

- The brake horsepower was also analysed in a similar fashion. Within the test range, the following relationship was established for the 0.5 inch clearance (Figure 5-9):

$$BHP = 62.7 + 0.0178\ Q \qquad (3)$$

where BHP is in horsepower
Q is in USGPM

- The pump efficiency was calculated using the equations presented above:

$$\text{Efficiency} = \frac{\text{Hydraulic HP} \times 100}{\text{Brake HP}} \qquad (4)$$

$$\text{Hydraulic HP} = Q \times H \times \frac{8.333}{33,000} \qquad (5)$$

Pump head, H can be expressed in terms of flow rate Q (Equation 1):

$$\text{Hydraulic HP} = Q \times (97.8 - 0.02234\ Q) \times \frac{8.333}{33,000} \qquad (6)$$

Using Equations (6) and (3), we obtain

$$\text{Efficiency} = \frac{(97.8 - 0.02234Q)}{(62.7 + 0.0178Q)} \times \frac{Q}{39.6} \qquad (7)$$

for the test pump, at an average solids concentration of 3.7%, 823 rpm and 0.5 inch clearance (Figure 5-9).

2. An analysis was carried out to see the effects of the propeller (Figure 5-11). However, no mathematical conclusion was reached due to either insufficient number of data points or the quality of the available data.

3. An attempt was made to compare the test pump to the USSR TPD-4A model pump (Table 5-6, Figure 5-12). The test pump characteristics were pro-rated to obtain its probable operating characteristics at 1000 rpm with 0.03 inch clearance. It was observed that the efficiency of the test pump would be expected to be slightly higher as well as flow rate and, consequently, the motor horsepower significantly larger, at a given head, when compared to TPD-4A.

4. The friction loss data for the test pipeline data was also analysed. The test velocity range was very limited (1.4 to 2.1 m/s) and therefore a linear relation was assumed to be sufficient in the test range. The following relation was obtained (Figure 5-14):

$$H = -0.694 + 0.458V + 0.048S \qquad (8)$$

Where " H" is head loss, ft/100 ft
"V" is velocity, ft/sec (4.5 V 6)
"S" is solids content, %

The friction loss was plotted onto the graph produced by the previous Swedish study for comparison (Figure 5-15).

5. Also, friction loss was pro-rated, using a $(D1/D2)^{2.17}$ factor, and a regression equation was established for a pipe of 755 mm to compare with previous USSR data. However, since:

   (a) the test diameter (300 mm) was significantly different than the USSR pipe diameter of 755 mm; and

   (b) the test pipe material PVC was much smoother than USSR steel pipe, it was considered that this manipulation of numbers did not have any mathematical significance to be able to compare with the USSR data.

6. Another analysis was made to relate the maximum allowable pipe length to the slurry flow rate. The larger the flow rate, the loss pump head is available and the larger is the system friction losses. Using Darcy's equation:

$$f = 5.37 \frac{(hL)}{(L)} \frac{d}{V^2} \qquad (9)$$

Where "V" is velocity, ft/sec
"d" is pipe diameter, inch

Equation (8) related the head loss per unit length in terms of velocity and solids content.

Equating the two equations:

$$f = \frac{5.37}{100} (-0.694 + 0.458V + 0.048S) \frac{(12)}{V^2}$$

$$f = \frac{64.41}{V^2 x 100} (-0.694 + 0.458V + 0.048S) \qquad (10$$

Expressing velocity in terms of flow rate:

$$f = \frac{-44.7 + 0.084Q + 3.09S}{8.028 \times 10^{-6} \times 100\ Q^2} \qquad (11)$$

Substituting Equation (11) into (9):

$$\frac{H}{100} = 0.0156 \times \frac{(L)}{(100)} \times (-44.7 + 0.084Q + 3.09S) \qquad (12)$$

for 12" pipe.

The head loss obtained from Equation (10) must be equal to the pump head. Combining equations (2) and (10) an equation is obtain relating maximum pipe length to flow rate and solids content (Figure 5-16).

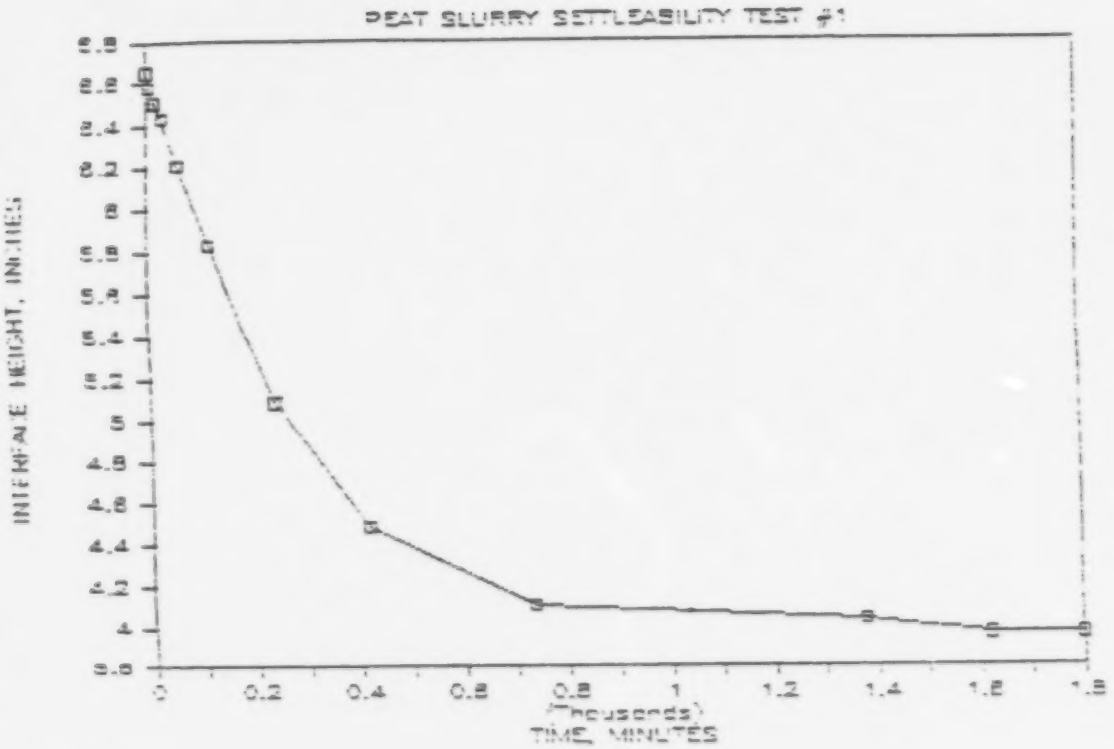
$$L_{max} = \frac{100.69 - 0.023Q - 0.369S}{-0.6973 + 0.00131Q + 0.0482S} \qquad (13)$$

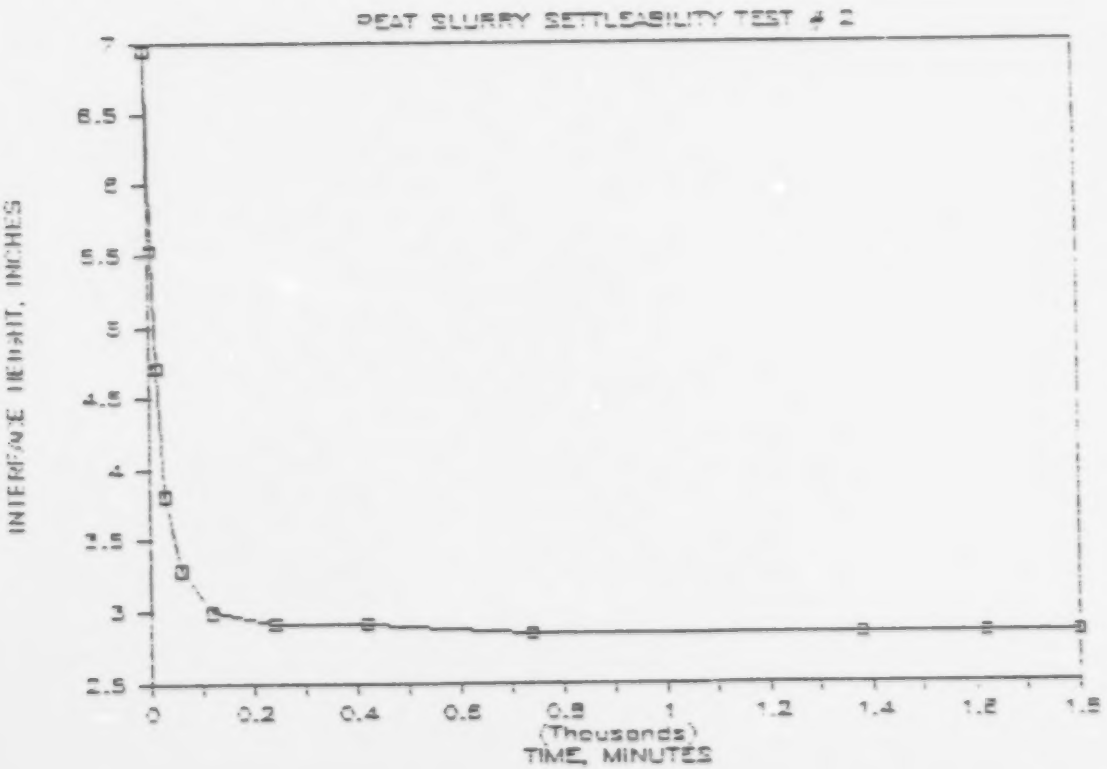
for the test system.

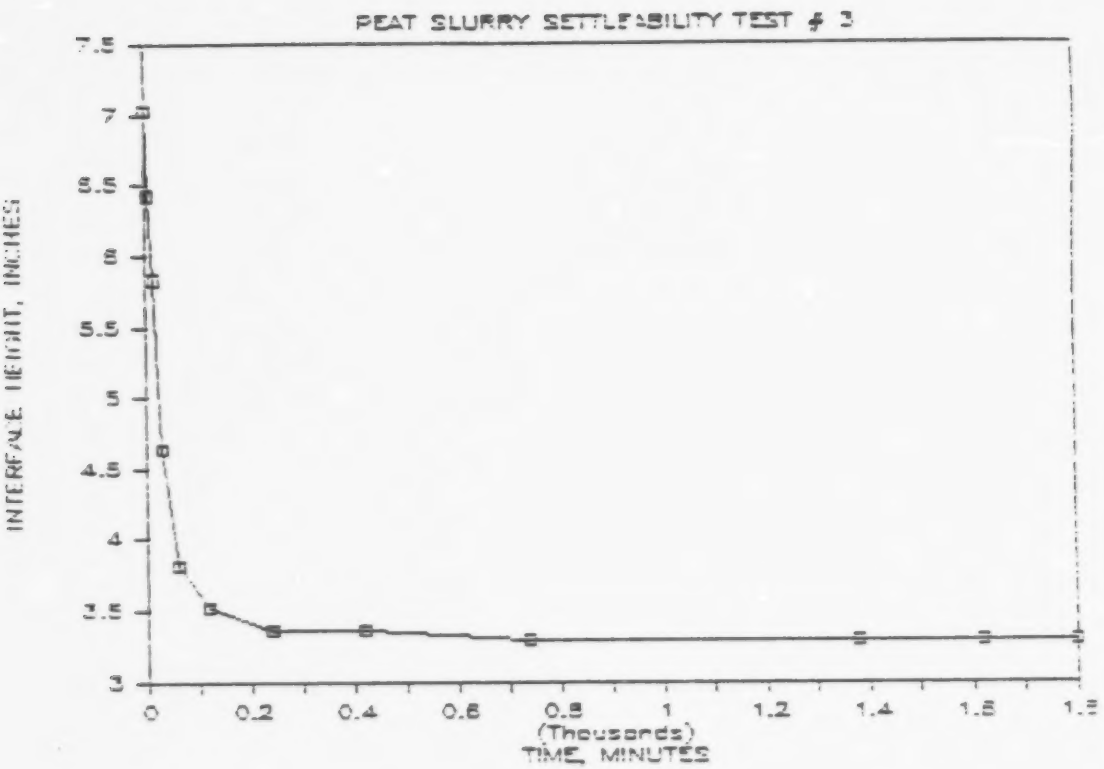
The maximum pipe length was also estimated for the same test system for the pump running at 1000 rpm and with 0.03 inch clearance. The results are depicted in Figure 5-16.

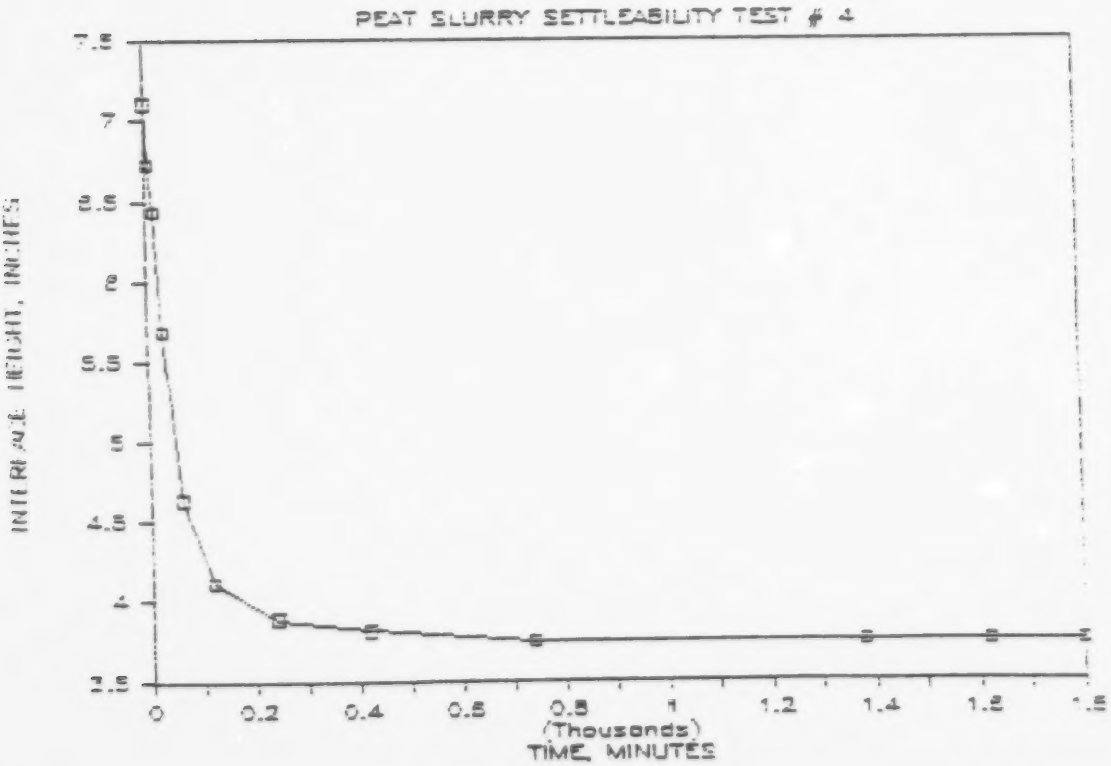
APPENDIX G

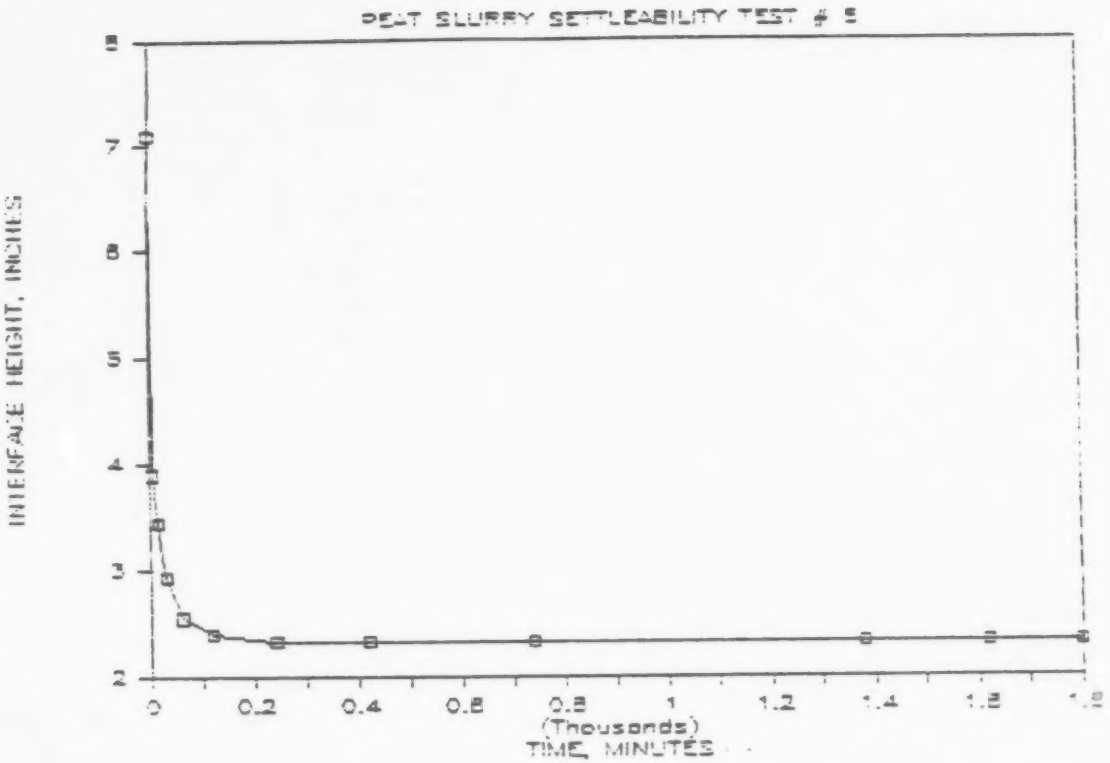
PEAT SLURRY SETTLABILITY CURVES

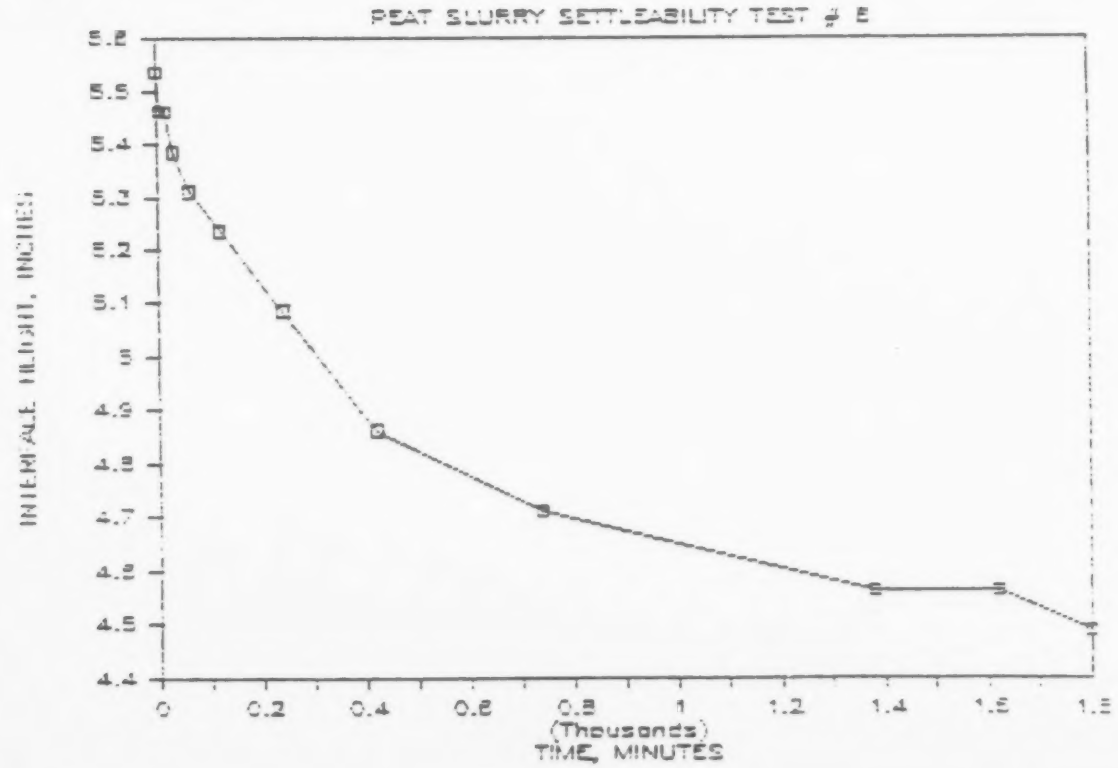

PEAT SLURRY SETTLEABILITY TEST #1
INTERFACE HEIGHT, INCHES
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES

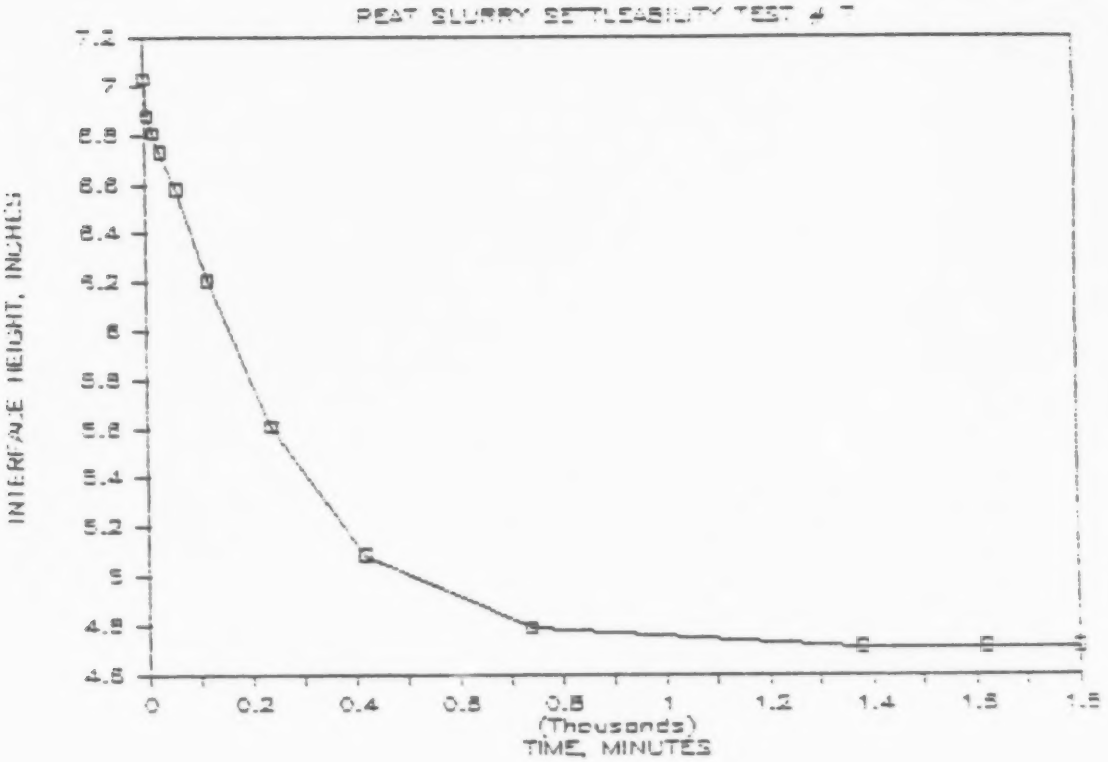

PEAT SLURRY SETTLEABILITY TEST # 2
INTERFACE HEIGHT, INCHES
6.5
5.5
4.5
3.5
2.5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES

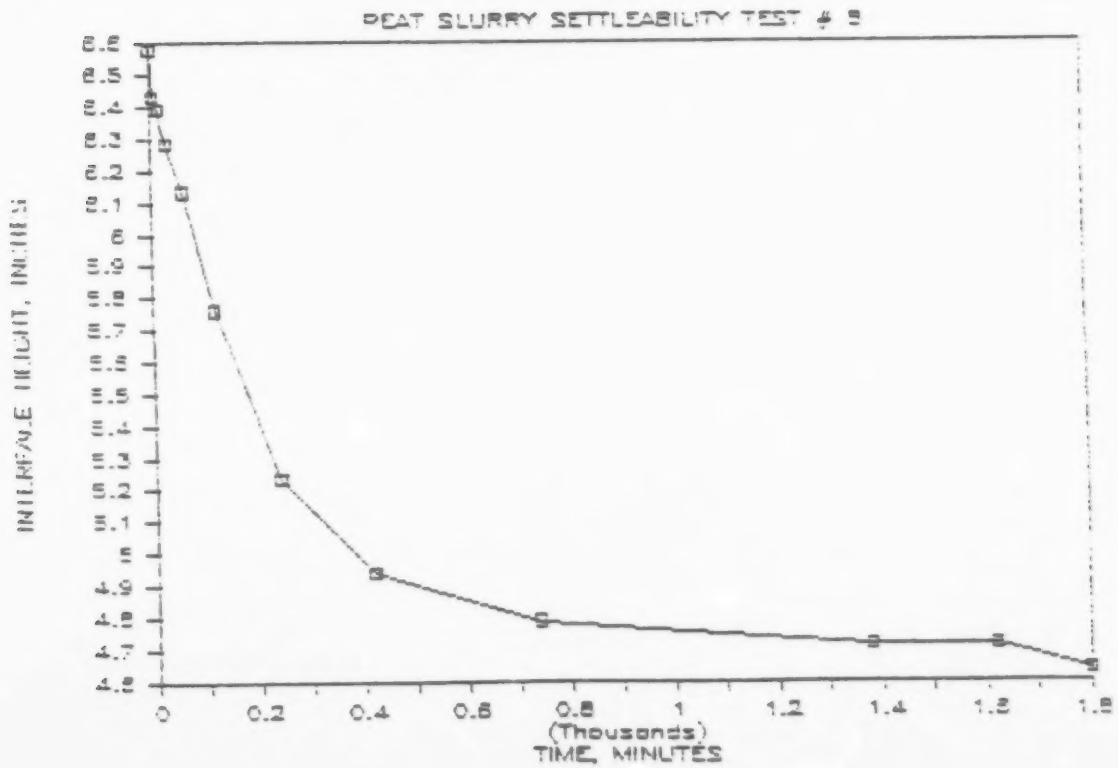

PEAT SLURRY SETTLEABILITY TEST # 3
INTERFACE HEIGHT, INCHES
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES

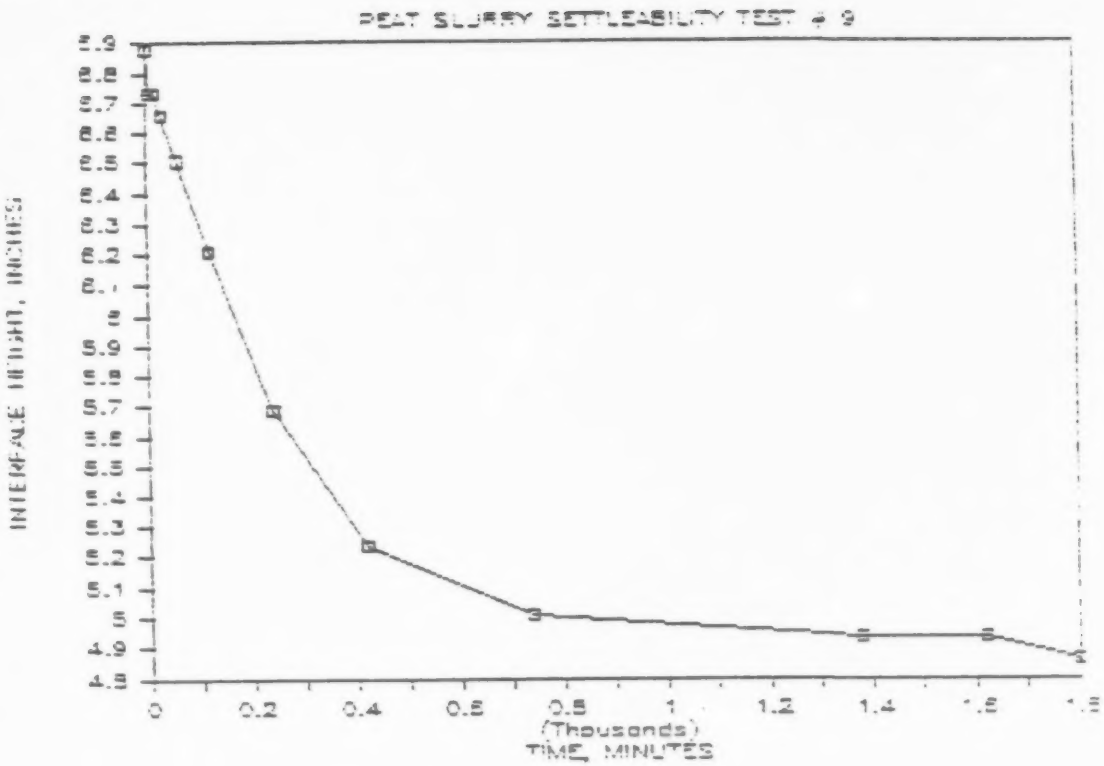

PEAT SLURRY SETTLEABILITY TEST # 4
INTERFACE HEIGHT, INCHES
7.5
7
6.5
6
5.5
5
4.5
4
3.5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES

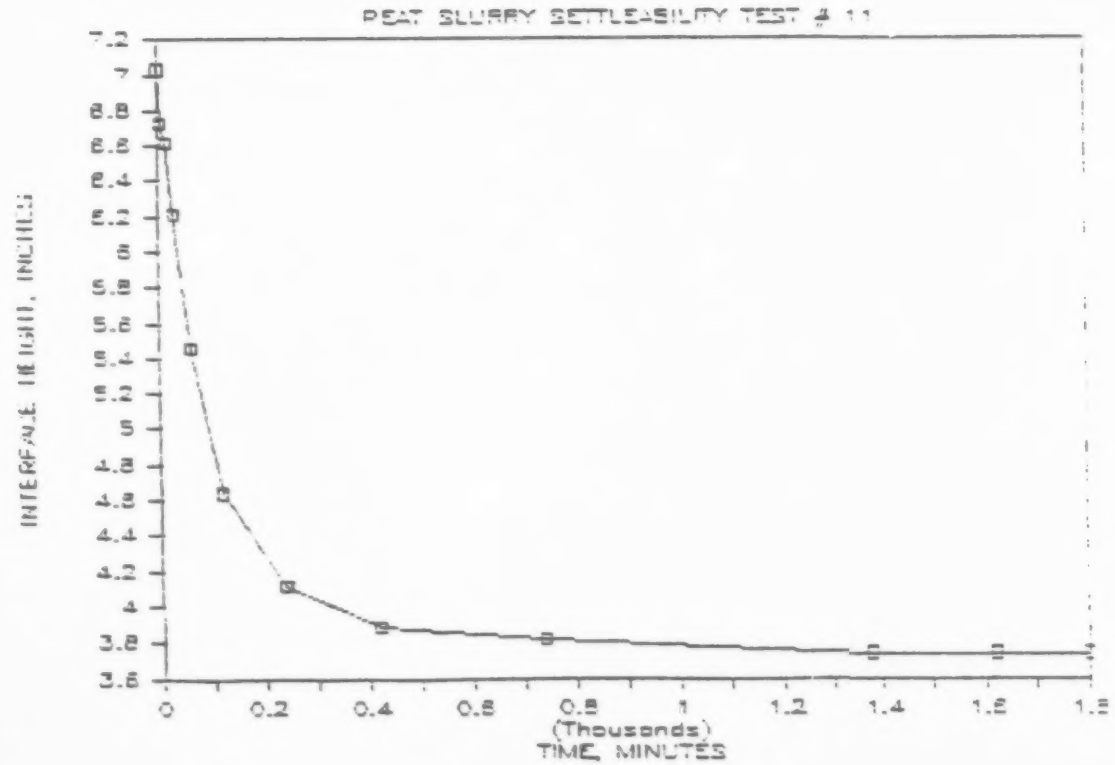

PEAT SLURRY SETTLEABILITY TEST # 5
INTERFACE HEIGHT, INCHES
8
7
6
5
4
3
2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
(Thousands)
TIME, MINUTES

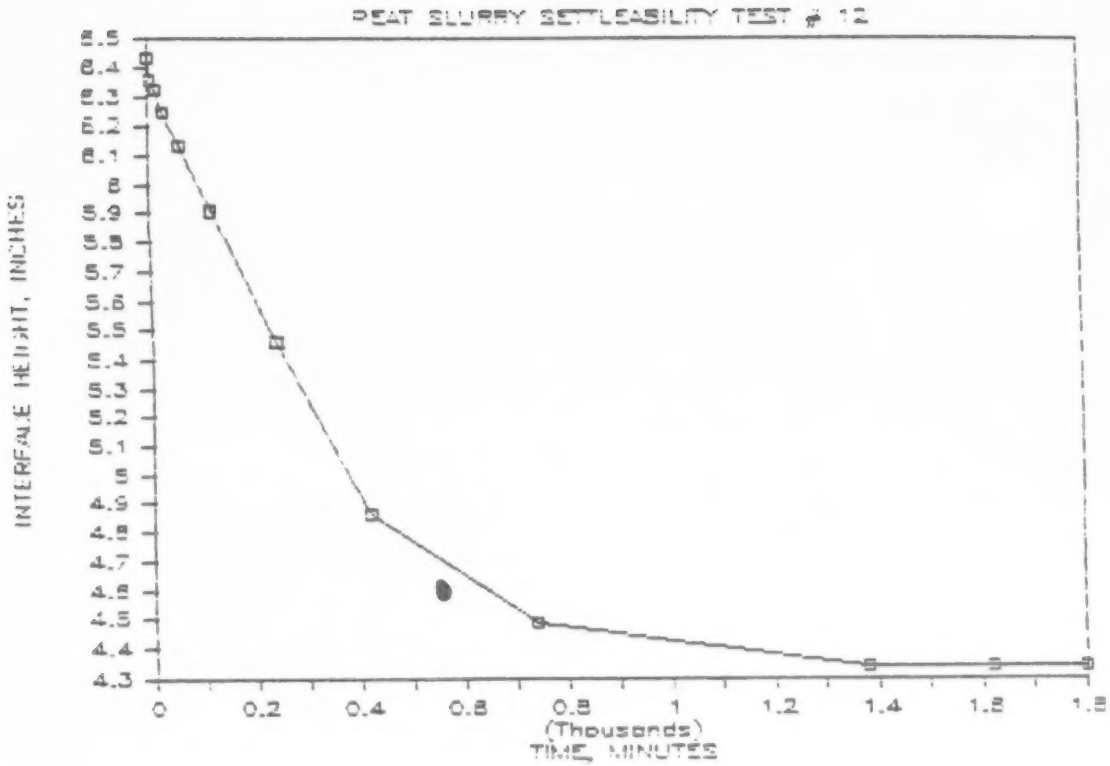

PEAT SLURRY SETTLEABILITY TEST # 6
INTERFACE HEIGHT, INCHES
5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES

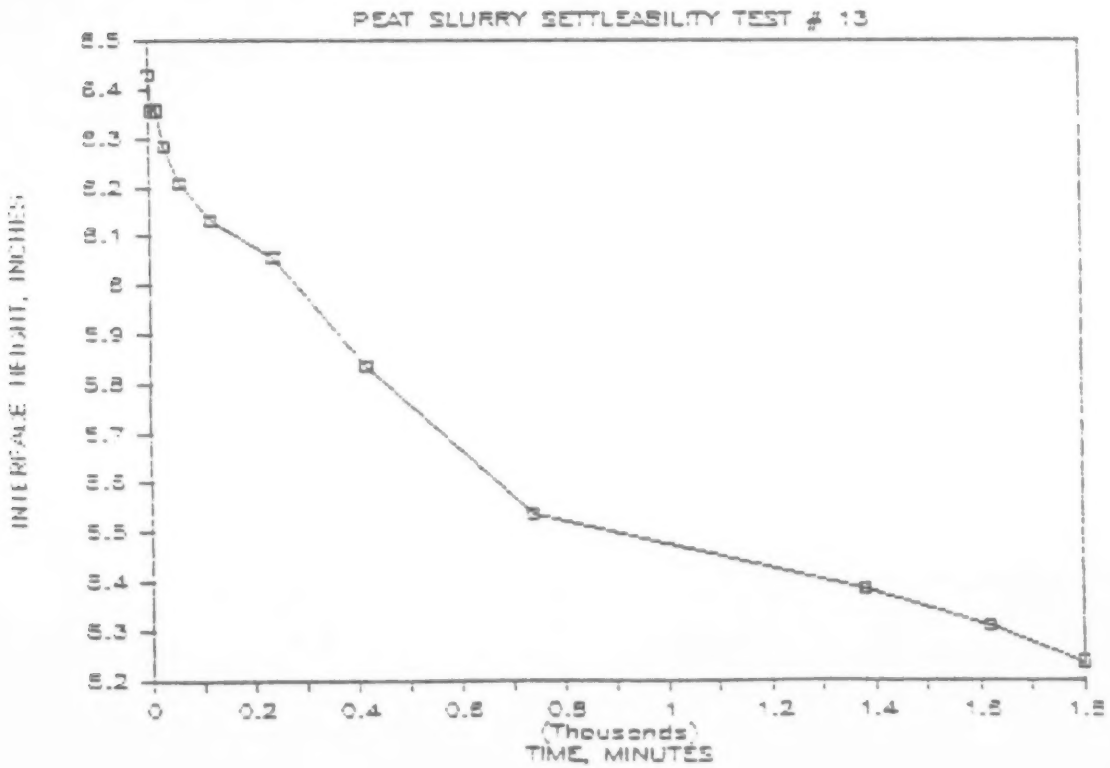

PEAT SLURRY SETTLEABILITY TEST #
INTERFACE HEIGHT, INCHES
TIME, MINUTES
(Thousands)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

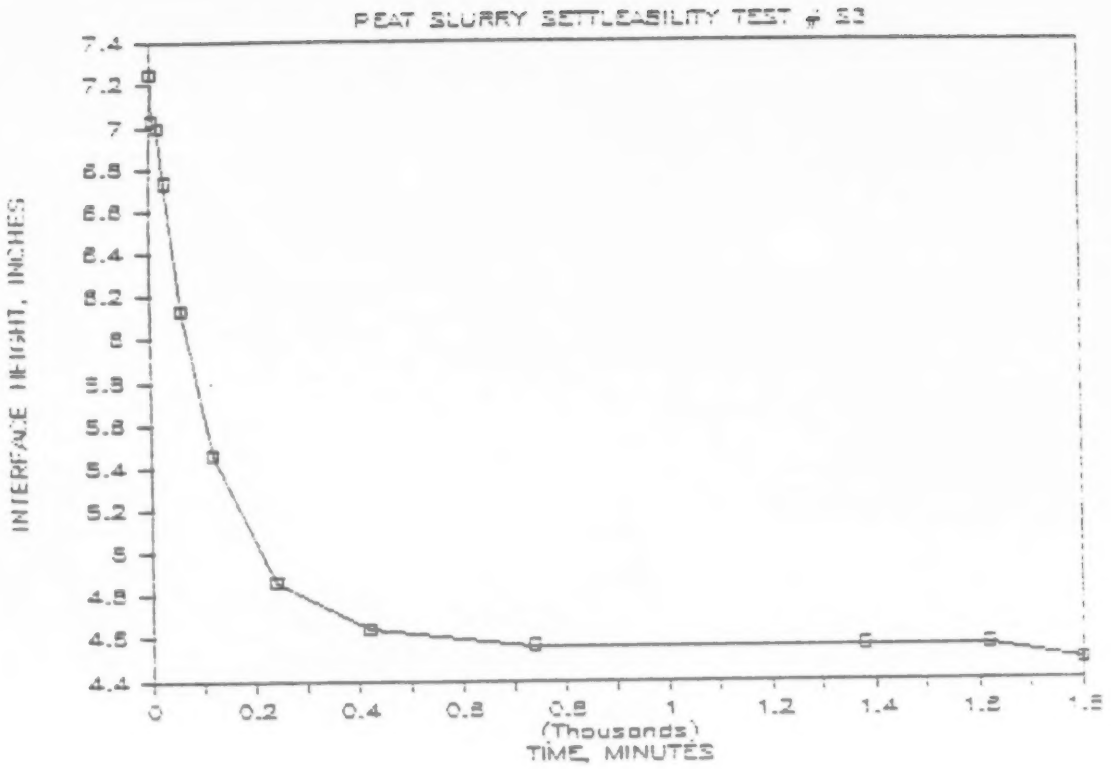

PEAT SLURRY SETTLEABILITY TEST # 5
INTERFACE HEIGHT, INCHES
TIME, MINUTES
(Thousands)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

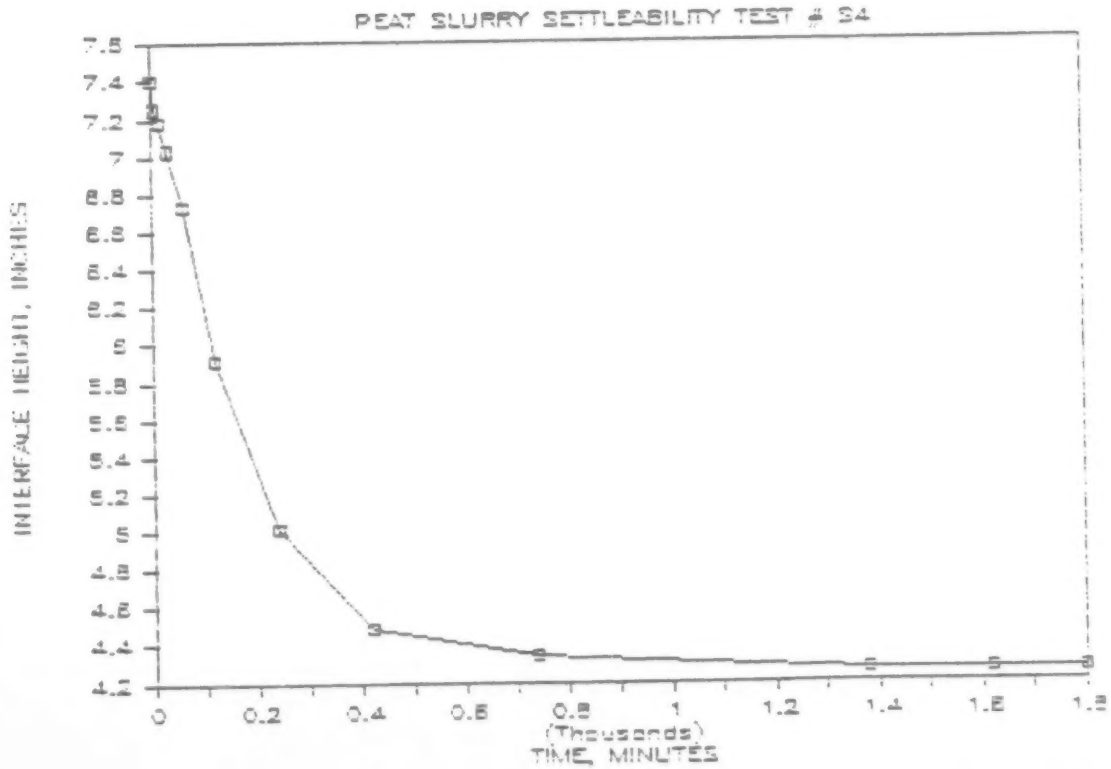

PEAT SLURRY SETTLEABILITY TEST # 9
INTERFACE HEIGHT, INCHES
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
(Thousands)
TIME, MINUTES

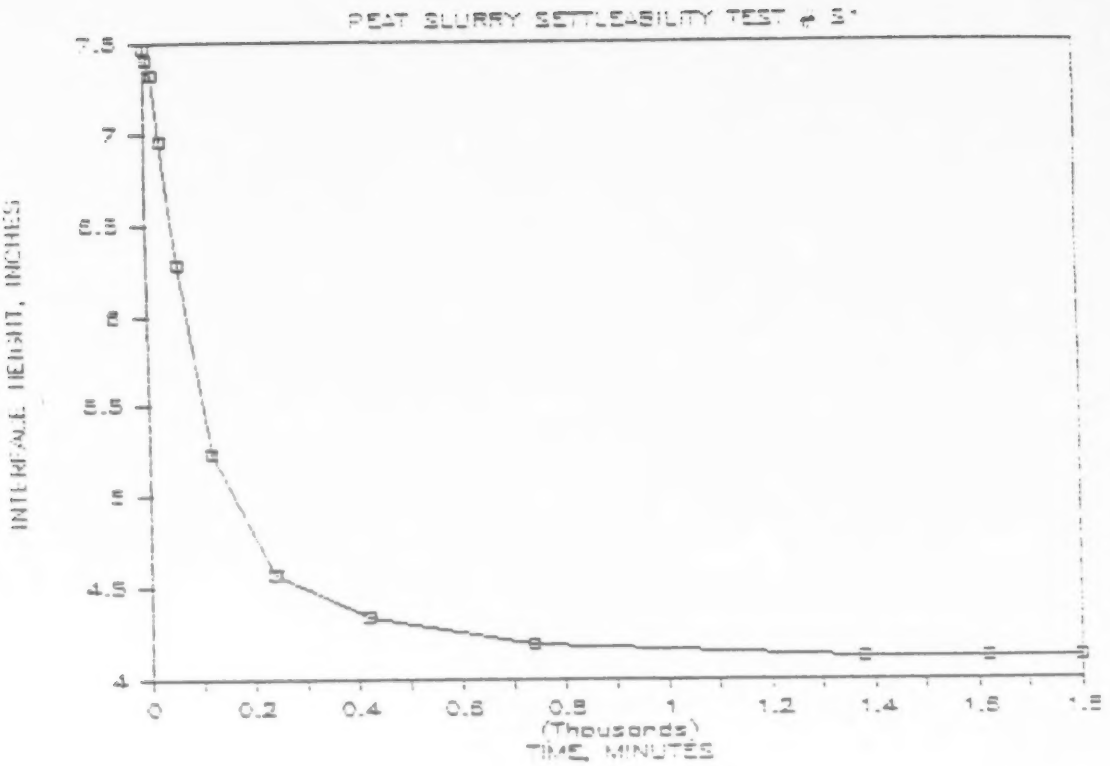

PEAT SLURRY SETTLEABILITY TEST # 11
INTERFACE HEIGHT, INCHES
3.6
4
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2
6.4
6.6
6.8
7
7.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES

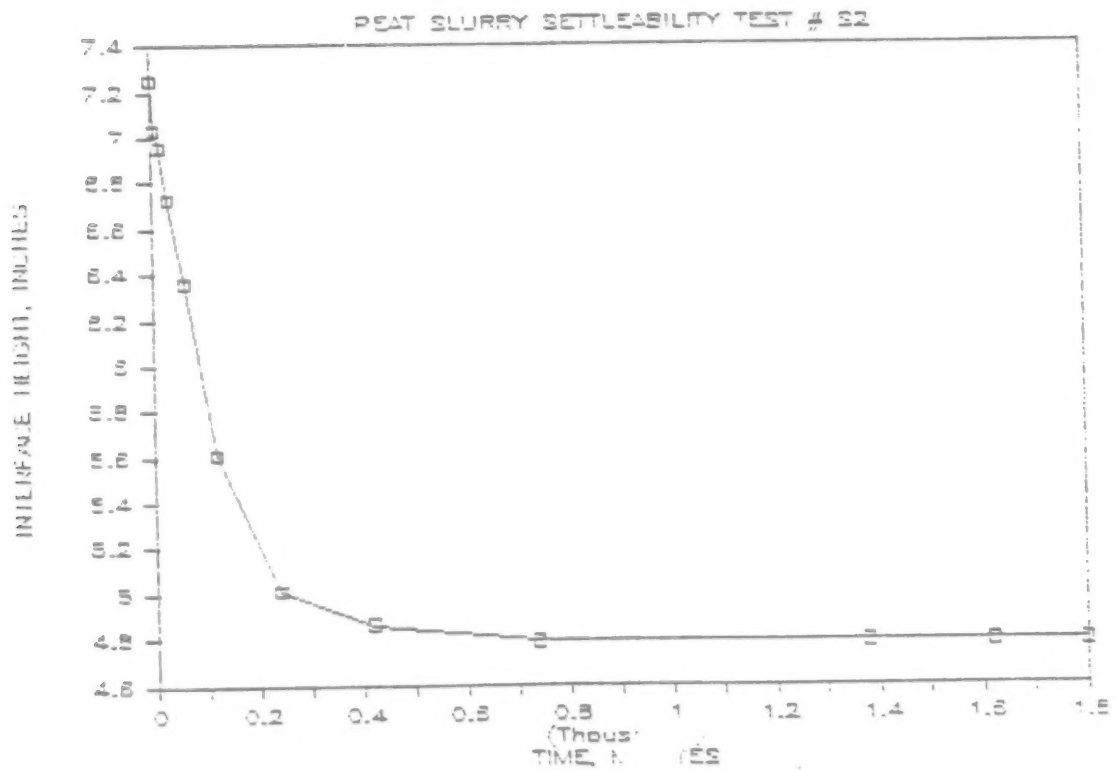

PEAT SLURRY SETTLEABILITY TEST # 12
INTERFACE HEIGHT, INCHES
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7
5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
4.3
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES

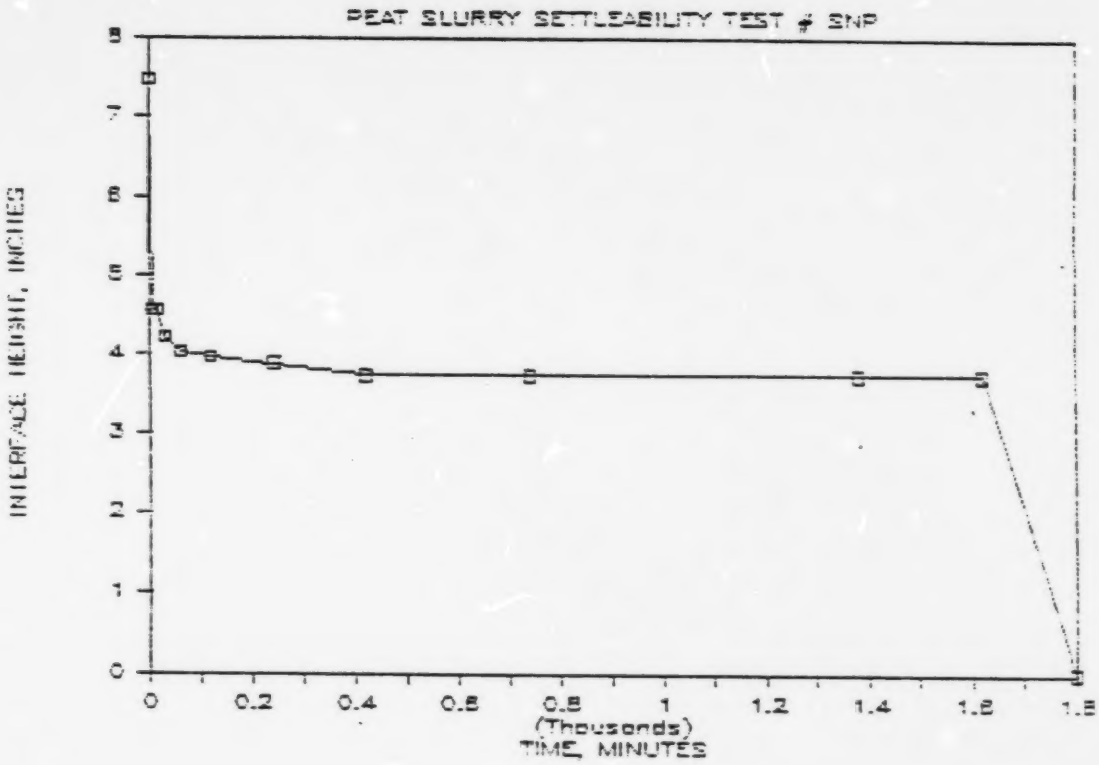

PEAT SLURRY SETTLEABILITY TEST # 13
INTERFACE HEIGHT, INCHES
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7
5.6
5.5
5.4
5.3
5.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES


PEAT SLURRY SETTLEABILITY TEST # S3
INTERFACE HEIGHT, INCHES
7.4
7.2
7
6.8
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES


PEAT SLURRY SETTLEABILITY TEST # S4
INTERFACE HEIGHT, INCHES
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
4.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES


PEAT SLURRY SETTLEABILITY TEST # S1
INTERFACE HEIGHT, INCHES
7.5
7
6.5
6
5.5
5
4.5
4
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES


PEAT SLURRY SETTLEABILITY TEST # S2
INTERFACE HEIGHT, INCHES
7.4
4.8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8


PEAT SLURRY SETTLEABILITY TEST # SNP
INTERFACE HEIGHT, INCHES
0
1
2
3
4
5
6
7
8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
(Thousands)
TIME, MINUTES

APPENDIX H

PEAT SLURRY DEWATERABILITY TEST DATA AND CURVES

TABLE H-1 - Peat Slurry Dewatering Test Results

TEST 1			TEST 2			TEST 3			TEST 4		
T1	V1	T1/V1	T2	V2	T2/V2	T3	V3	T3/V3	T4	V4	T4/V4
1.0	10.0	0.10	0.6	10.0	0.06	0.5	10.0	0.05	0.9	10.0	0.09
2.5	20.0	0.13	1.8	20.0	0.09	1.5	20.0	0.08	3.3	25.0	0.13
4.5	30.0	0.15	3.3	30.0	0.11	3.0	30.0	0.10	4.2	30.0	0.14
6.5	40.0	0.16	5.1	40.0	0.13	4.8	40.0	0.12	6.5	40.0	0.16
9.0	50.0	0.18	7.0	50.0	0.14	7.7	55.0	0.14	9.0	50.0	0.18
11.2	60.0	0.19	10.3	65.0	0.16	8.5	60.0	0.14	11.5	60.0	0.19
15.5	70.0	0.22	11.5	70.0	0.16	11.2	70.0	0.16	14.8	70.0	0.21
			14.8	80.0	0.18	14.3	80.0	0.18	21.0	79.0	0.27

TEST 5			TEST 6			TEST 7			TEST 8		
T5	V5	T5/V5	T6	V6	T6/V6	T7	V7	T7/V7	T8	V8	T8/V8
0.9	10.0	0.09	1.5	10.0	0.15	1.1	10.0	0.11	1.1	10.0	0.11
2.3	20.0	0.12	4.0	20.0	0.20	2.9	20.0	0.14	3.1	20.0	0.16
5.0	35.0	0.14	7.0	30.0	0.23	5.0	30.0	0.17	5.5	30.0	0.18
7.3	45.0	0.16	10.8	40.0	0.27	7.5	40.0	0.19	8.8	40.0	0.22
8.5	50.0	0.17	13.8	45.0	0.31	13.3	60.0	0.22	12.0	50.0	0.24
12.2	65.0	0.19	25.0	49.0	0.51	15.3	65.0	0.23	17.0	60.0	0.28
13.8	70.0	0.20				17.5	70.0	0.25	30.0	67.0	0.45
15.3	75.0	0.20									

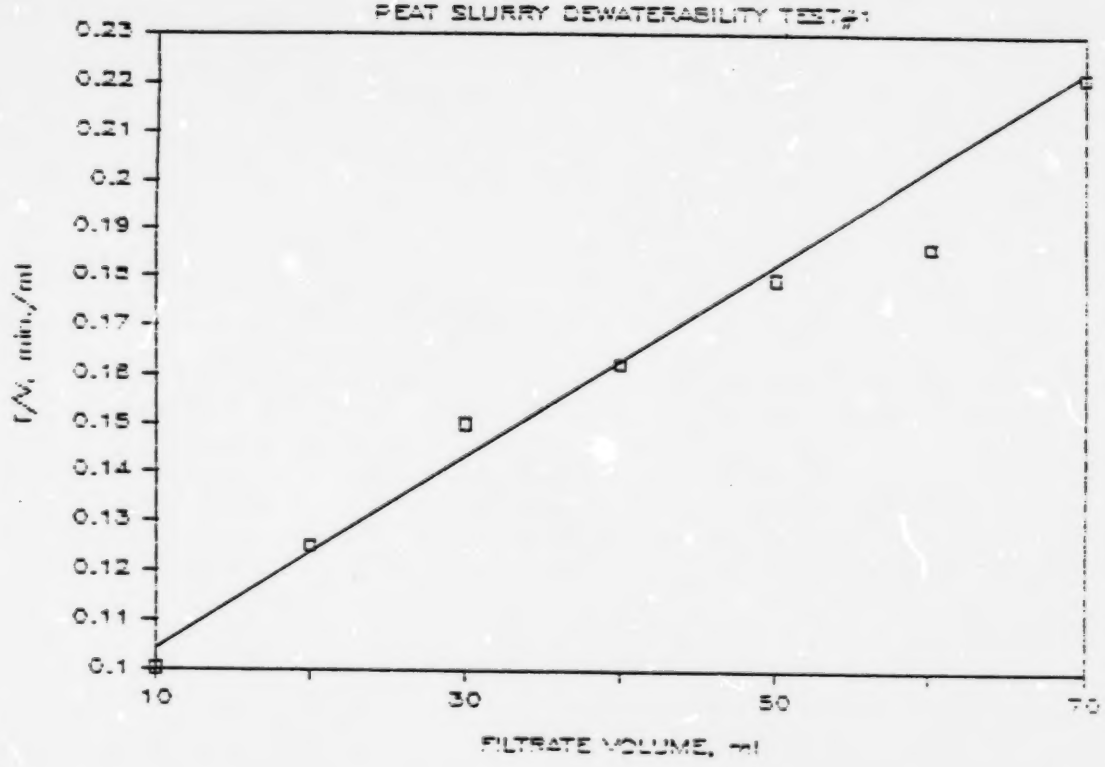
TEST 9			TEST 11			TEST 12			TEST 13		
T9	V9	T9/V9	T11	V11	T11/V11	T12	V12	T12/V12	T13	V13	T13/V13
0.8	10.0	0.08	0.7	10.0	0.07	1.2	10.0	0.12	1.3	10.0	0.13
2.5	25.0	0.10	2.0	20.0	0.10	3.0	20.0	0.15	3.3	20.0	0.17
4.8	30.0	0.16	3.5	30.0	0.12	5.3	30.0	0.18	5.5	30.0	0.18
7.0	40.0	0.18	5.9	40.0	0.15	8.0	40.0	0.20	8.5	40.0	0.21
9.8	50.0	0.20	8.5	50.0	0.17	11.0	50.0	0.22	12.0	50.0	0.24
12.8	60.0	0.21	14.3	70.0	0.20	14.5	60.0	0.24	18.0	60.0	0.30

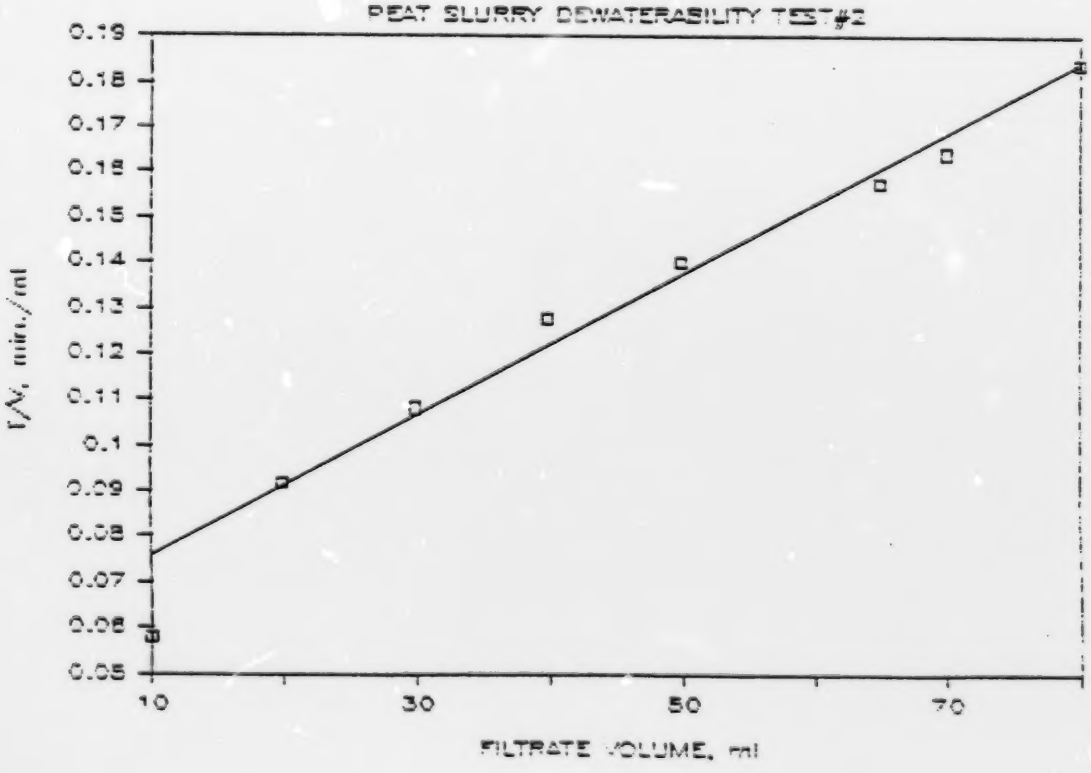
TABLE H-1

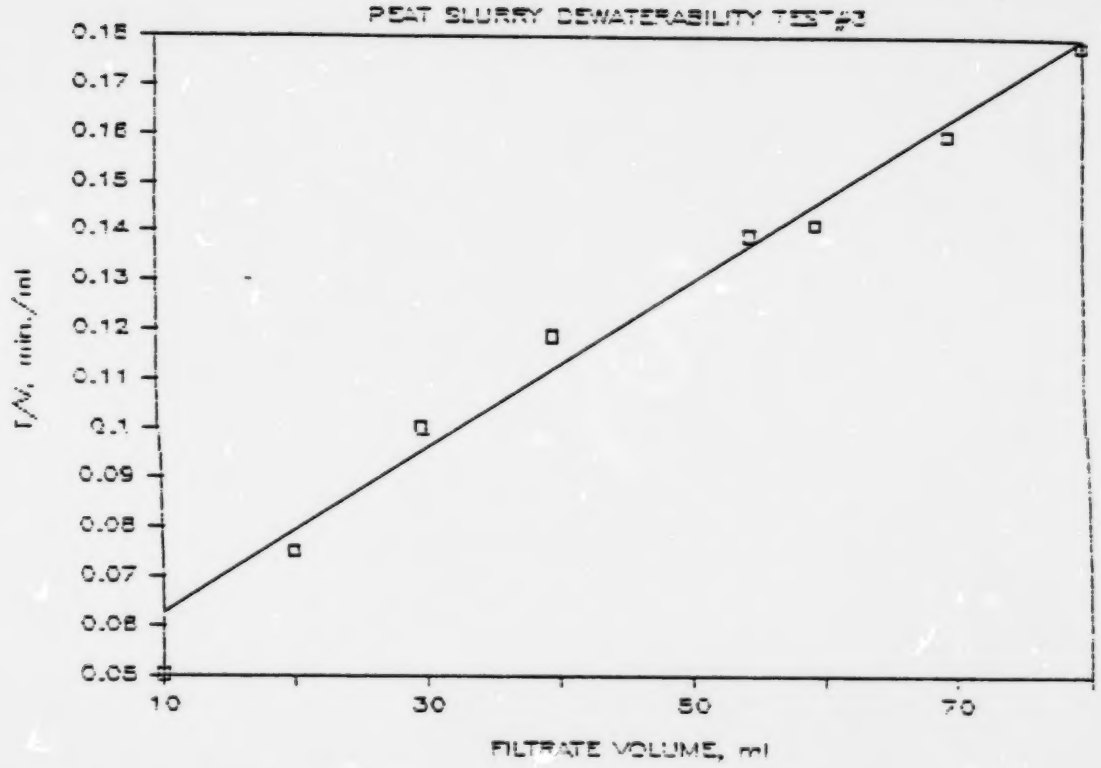
Contd.

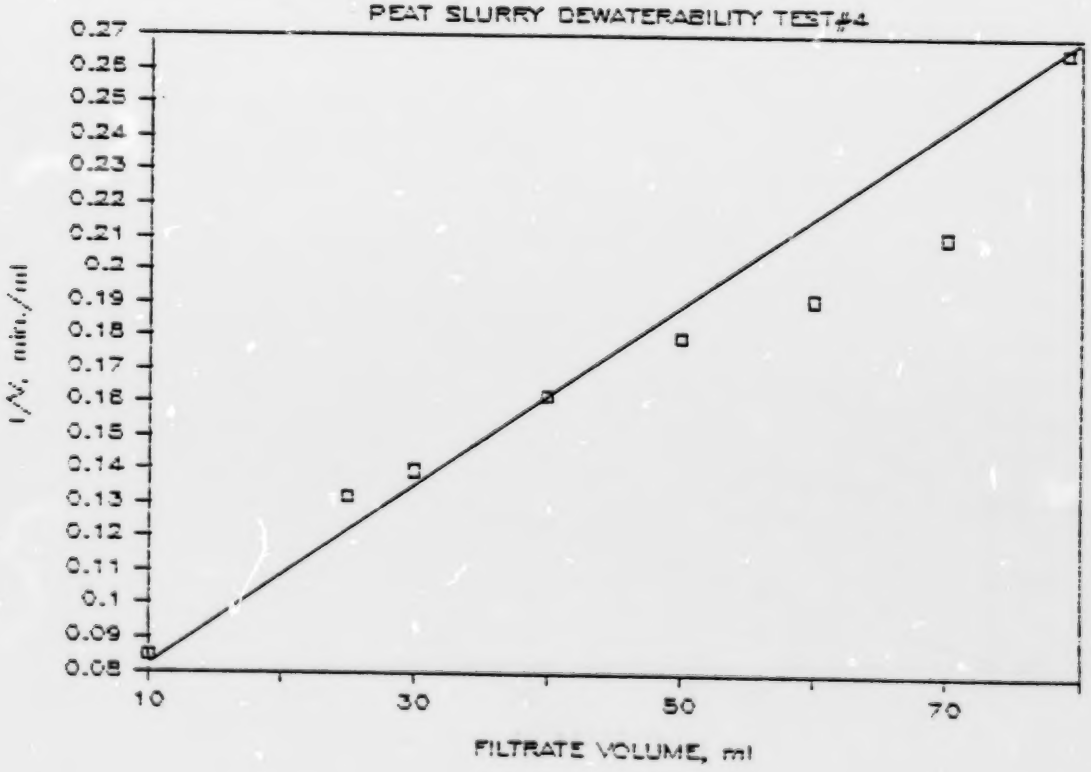
TEST S1			TEST S2			TEST S3			TEST S4		
TS1	VS1	TS1/VS1	TS2	VS2	TS2/VS2	TS3	VS3	TS3/VS3	TS4	VS4	TS4/VS4
0.9	10.0	0.09	1.5	10.0	0.15	1.5	10.0	0.15	1.3	10.0	0.13
2.8	20.0	0.14	3.8	20.0	0.19	3.8	20.0	0.19	3.2	20.0	0.16
5.0	30.0	0.17	6.5	30.0	0.22	6.8	30.0	0.23	5.8	30.0	0.19
7.9	40.0	0.20	10.0	40.0	0.25	12.3	45.0	0.27	10.3	45.0	0.23
12.3	55.0	0.22	13.3	50.0	0.27	16.5	55.0	0.30	12.0	50.0	0.24
17.8	70.0	0.25	17.5	60.0	0.29	19.5	60.0	0.33	15.3	60.0	0.26
			20.0	65.0	0.31	25.0	70.0	0.36	19.3	70.0	0.28
			22.7	70.0	0.32						

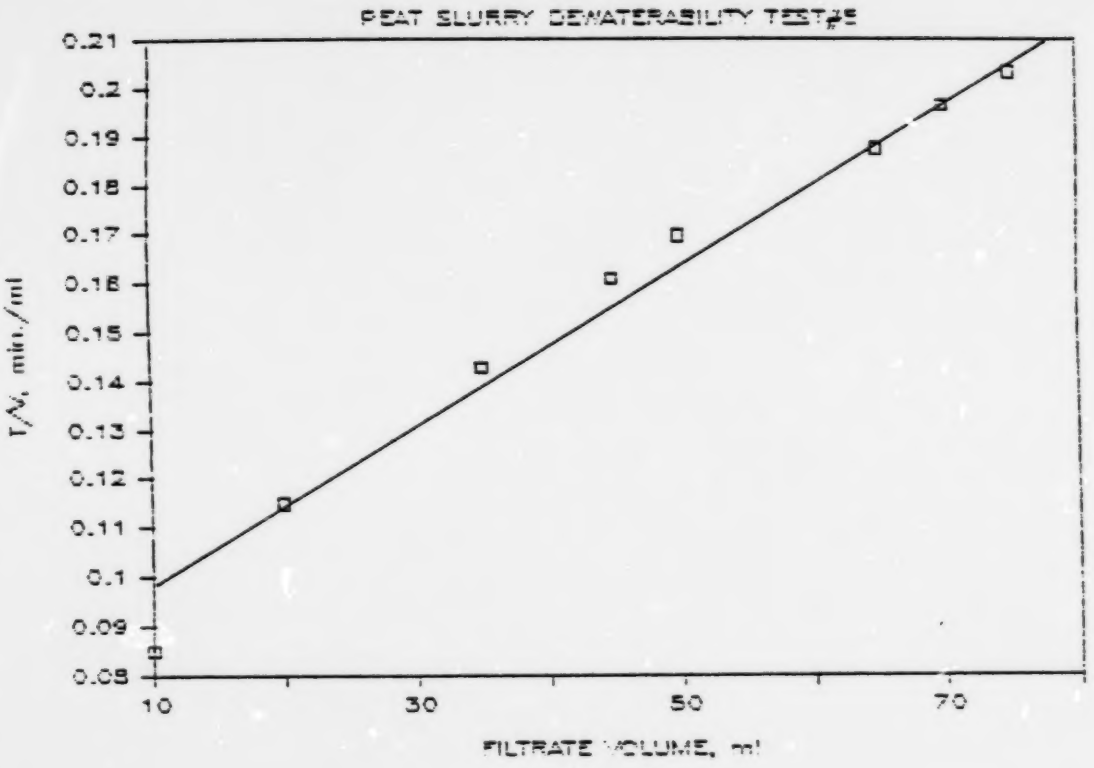
TEST SNP		
TSNP	VSNP	TSNP/VSNP
0.5	10.0	0.05
2.0	20.0	0.10
4.0	30.0	0.13
6.0	40.0	0.15
8.5	50.0	0.17
11.3	60.0	0.19
14.0	70.0	0.20
17.3	80.0	0.22

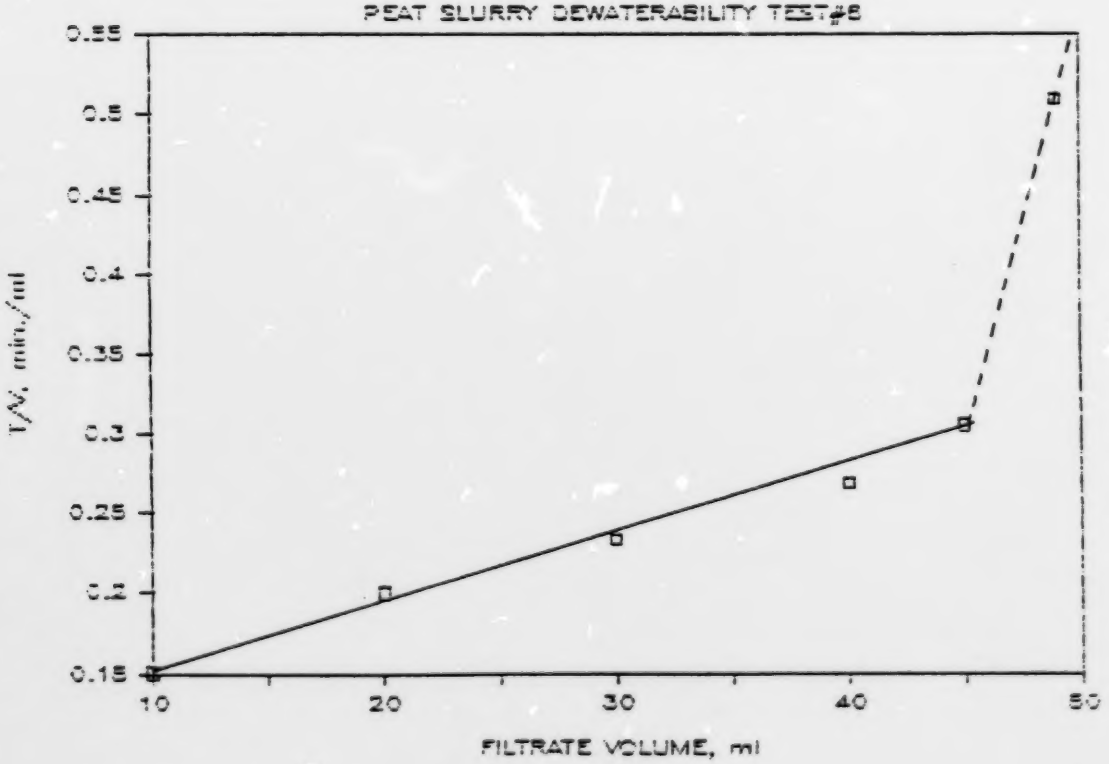

PEAT SLURRY DEWATERABILITY TEST#1
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
t/V, min./ml
10
30
50
70
FILTRATE VOLUME, ml

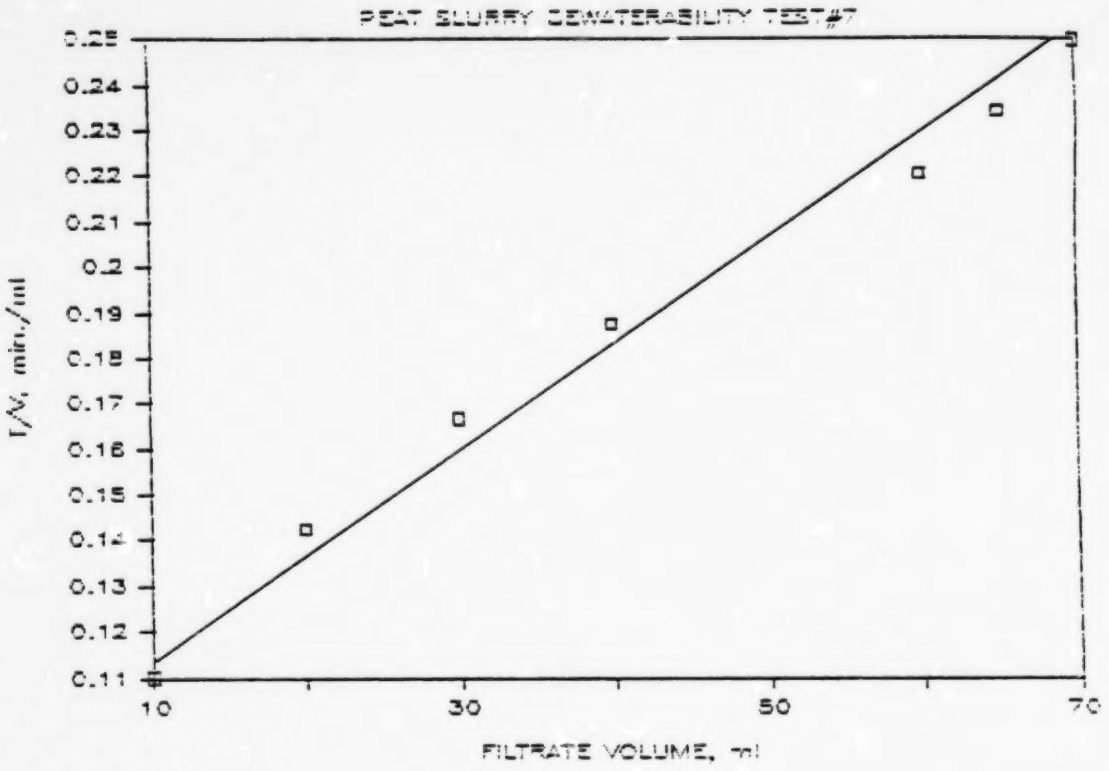

PEAT SLURRY DEWATERABILITY TEST#2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
t/V, min./ml
10
30
50
70
FILTRATE VOLUME, ml

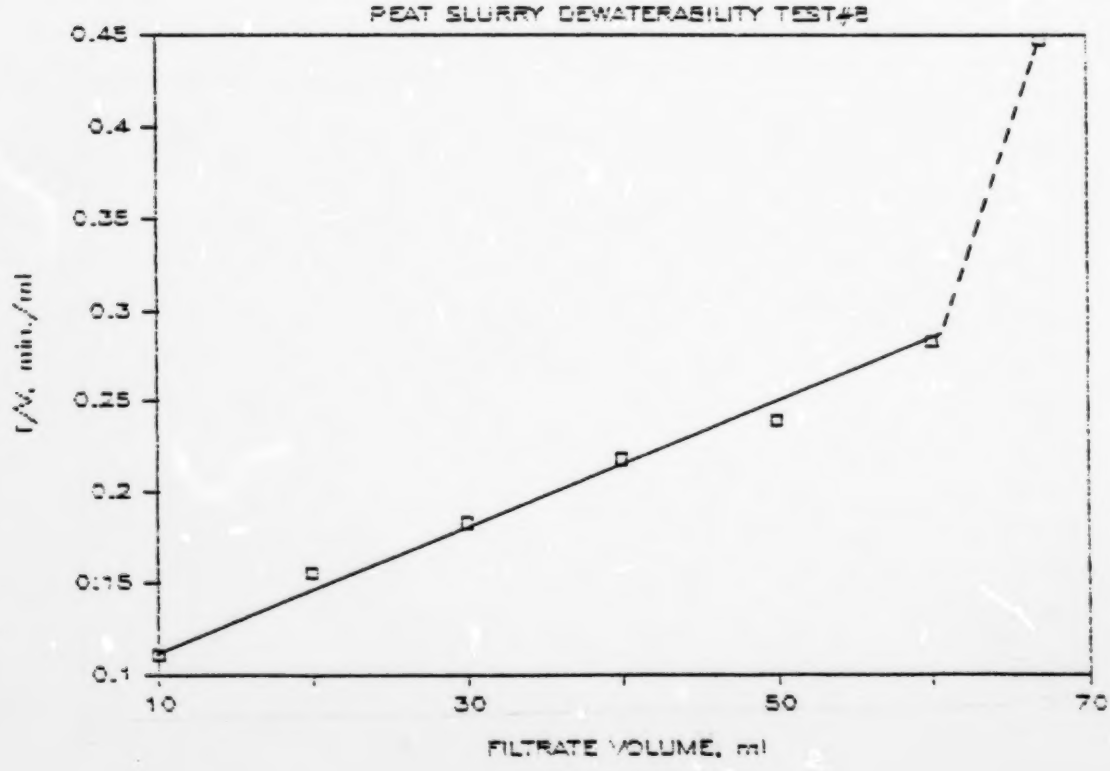

PEAT SLURRY DEWATERABILITY TEST#3
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
t/V, min./ml
10
30
50
70
FILTRATE VOLUME, ml

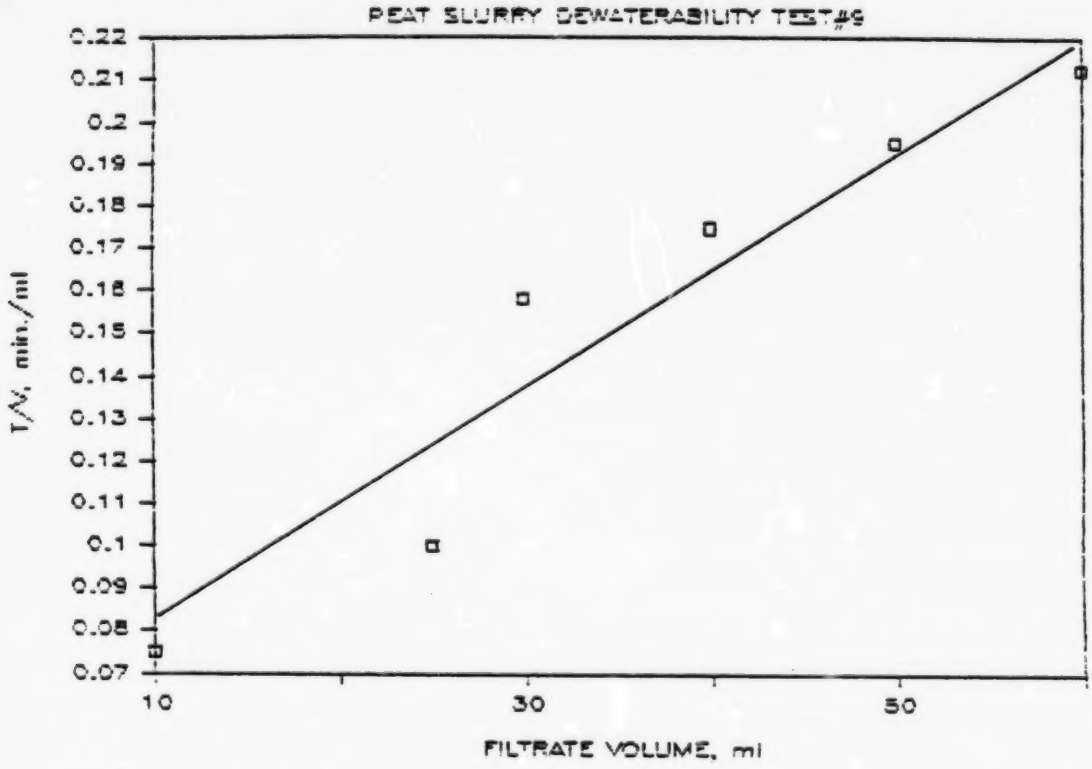

PEAT SLURRY DEWATERABILITY TEST#4
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
t/V, min./ml
10
30
50
70
FILTRATE VOLUME, ml

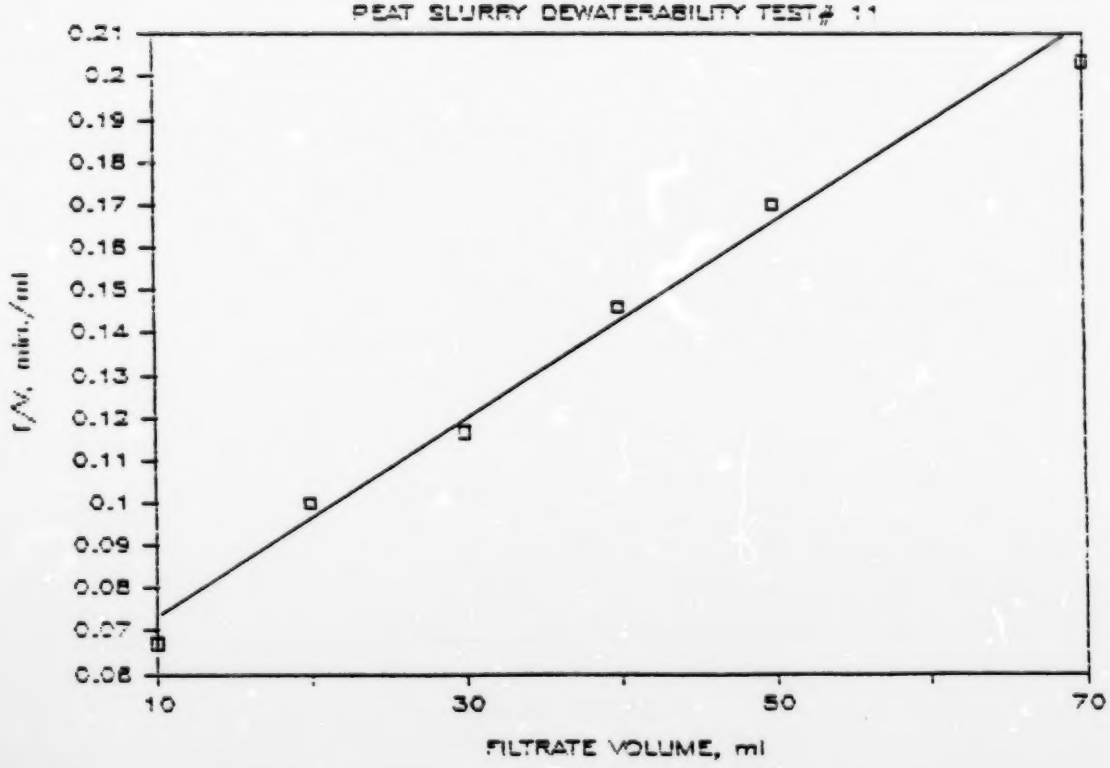

PEAT SLURRY DEWATERABILITY TEST#5
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
T/V, min./ml
10
30
50
70
FILTRATE VOLUME, ml

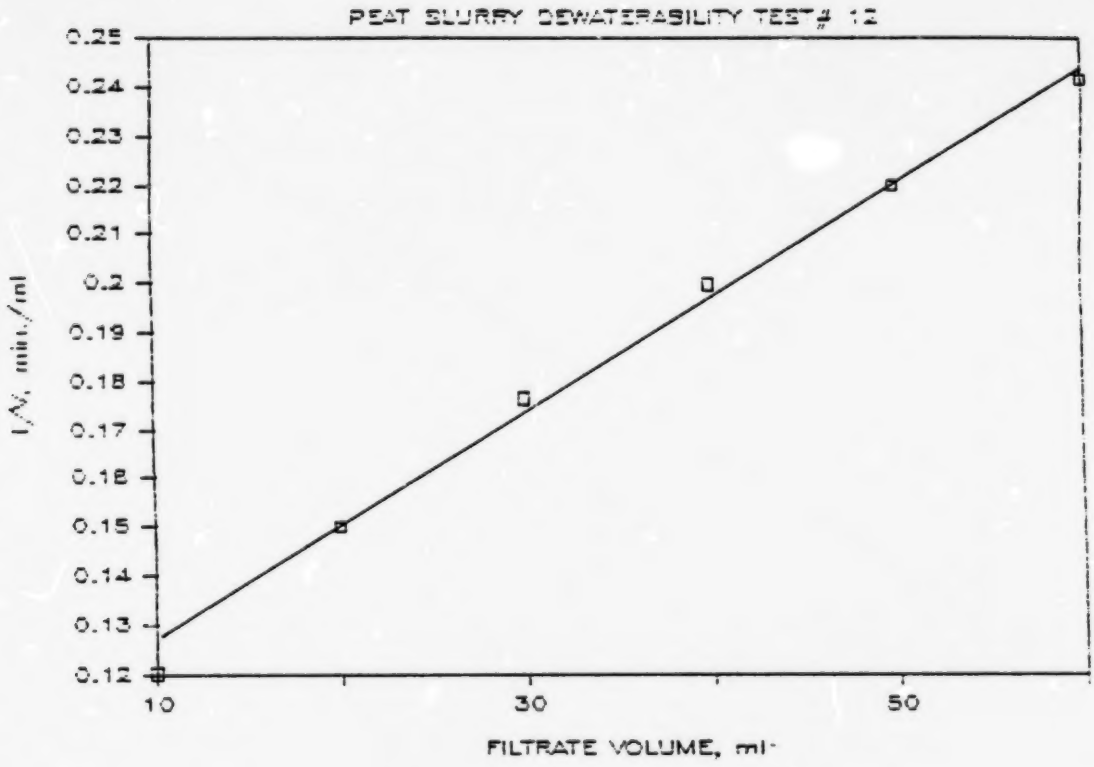

PEAT SLURRY DEWATERABILITY TEST#8
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
T/V, min./ml
10
20
30
40
50
FILTRATE VOLUME, ml

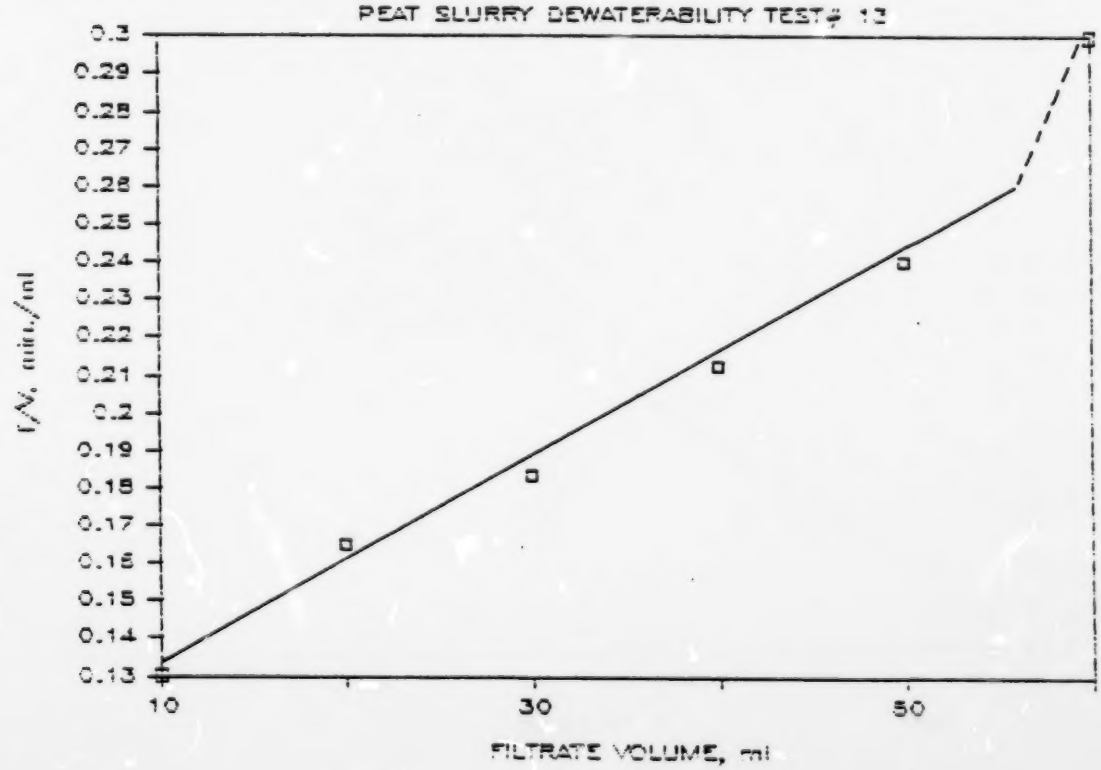

PEAT SLURRY DEWATERABILITY TEST#7
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
t/V, min./ml
10
30
50
70
FILTRATE VOLUME, ml

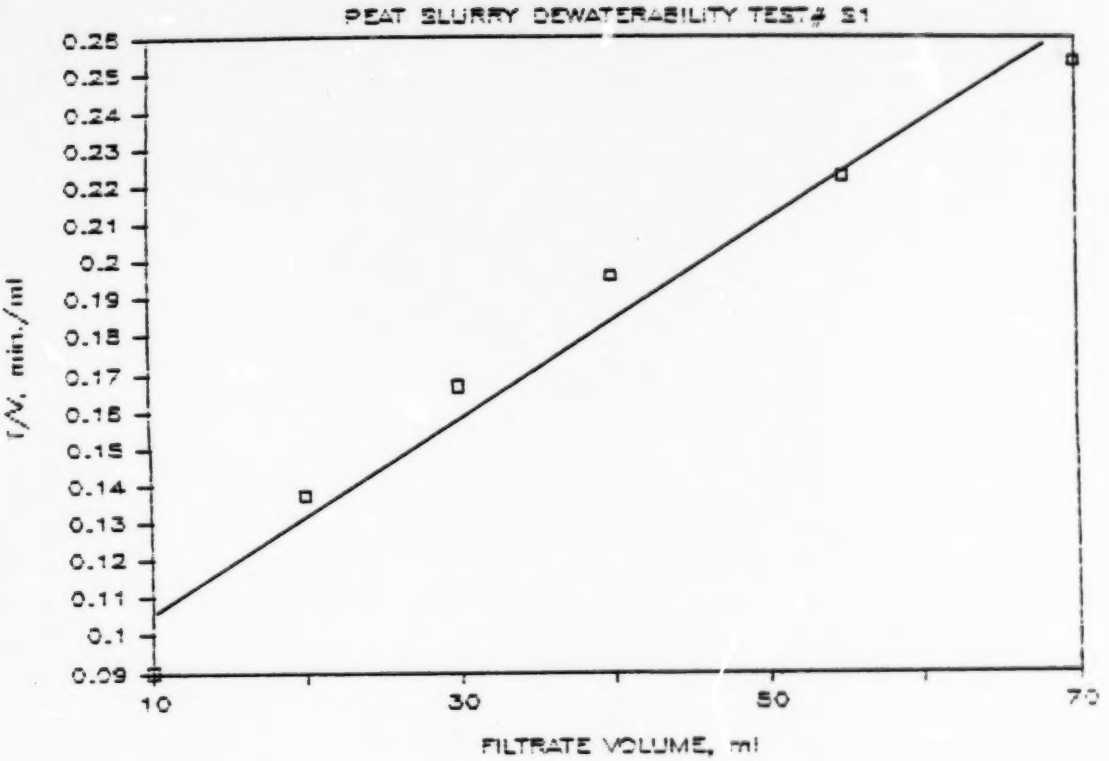

PEAT SLURRY DEWATERABILITY TEST#8
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
t/V, min./ml
10
30
50
70
FILTRATE VOLUME, ml

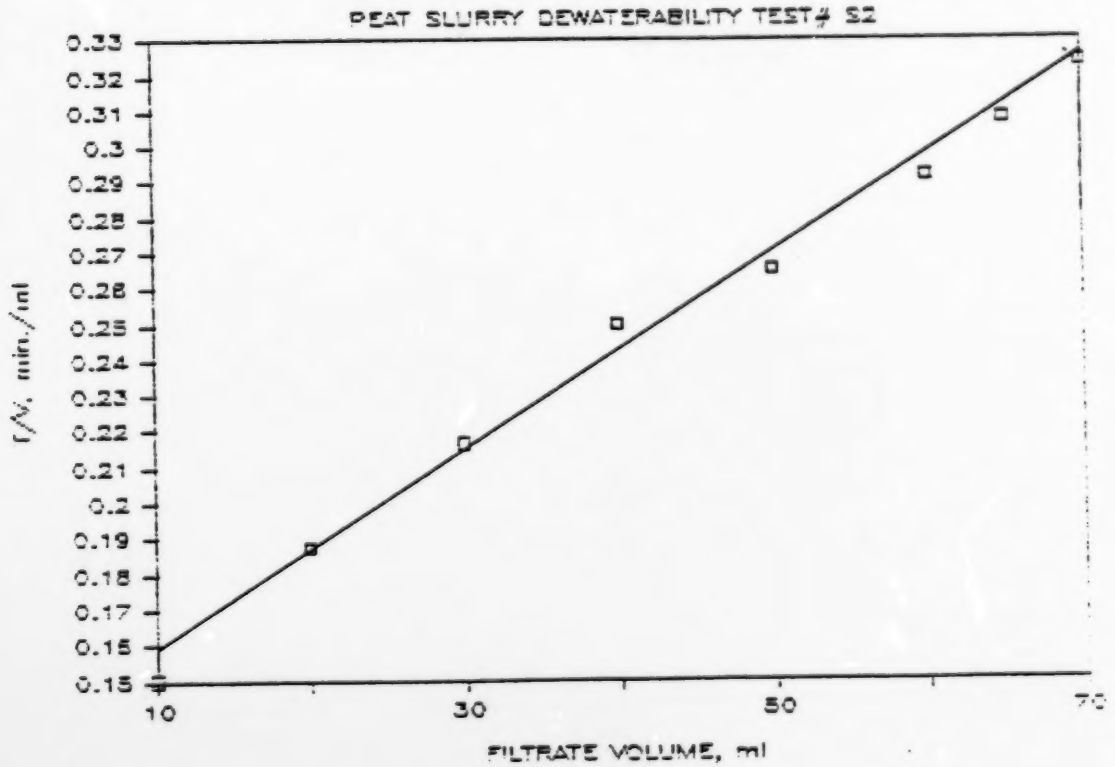

PEAT SLURRY DEWATERABILITY TEST#9
T/V, min./ml
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
10
30
50
FILTRATE VOLUME, ml

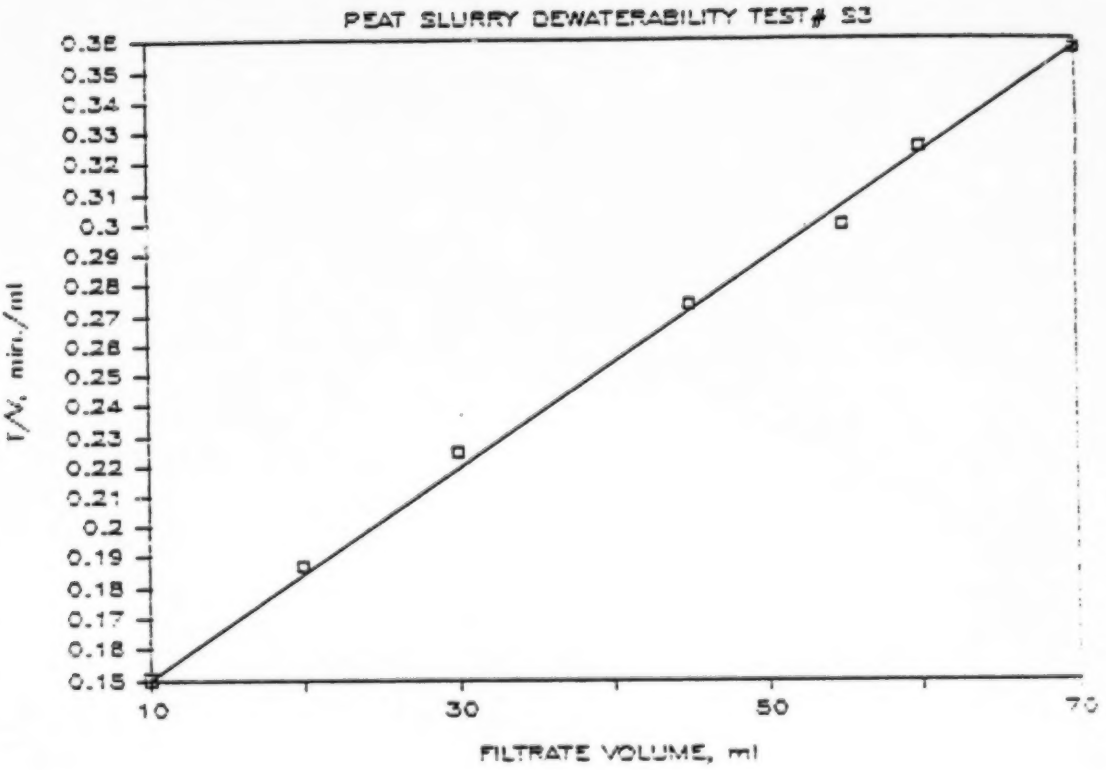

PEAT SLURRY DEWATERABILITY TEST# 11
T/V, min./ml
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
10
30
50
70
FILTRATE VOLUME, ml

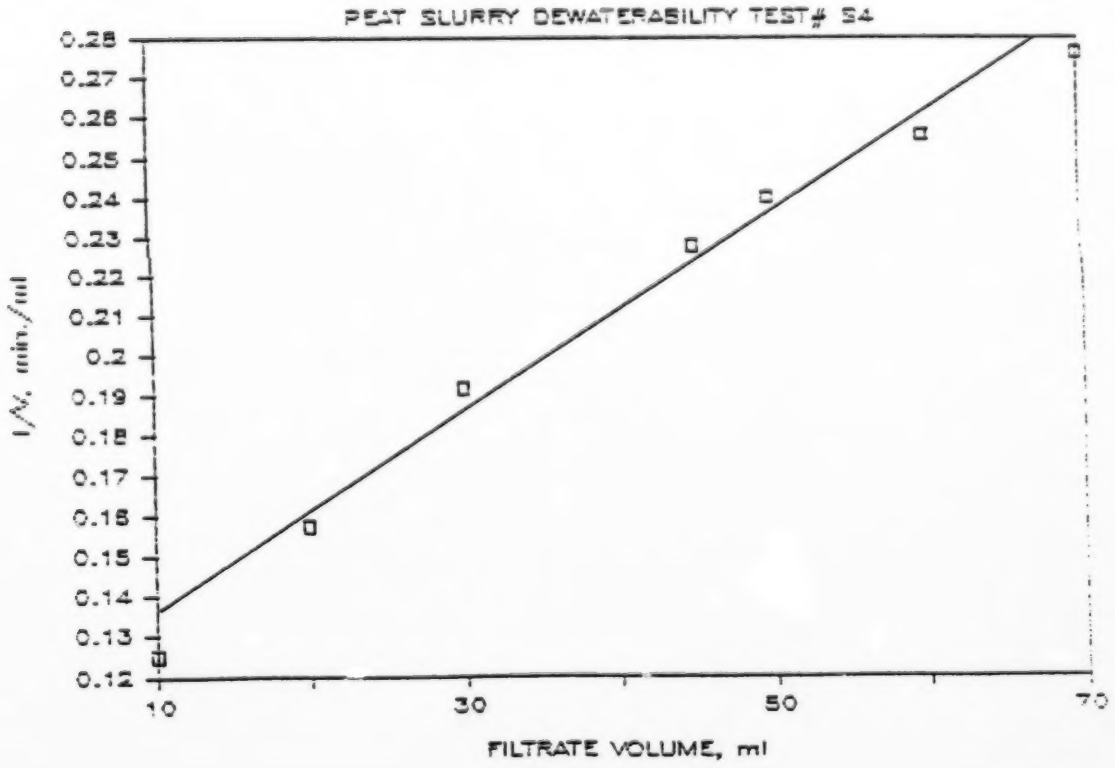

PEAT SLURRY DEWATERABILITY TEST# 12
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
t/V, min./ml
10
30
50
FILTRATE VOLUME, ml

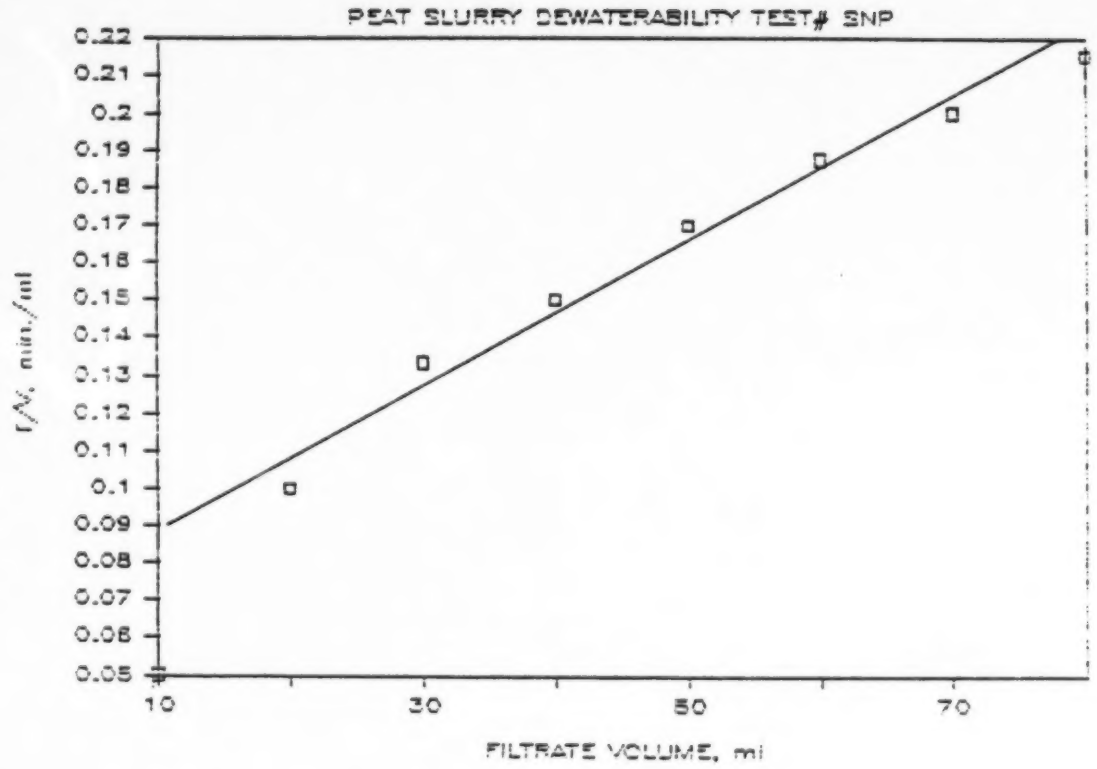

PEAT SLURRY DEWATERABILITY TEST# 13
0.3
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
t/V, min./ml
10
30
50
FILTRATE VOLUME, ml


PEAT SLURRY DEWATERABILITY TEST# S1
t/V, min./ml
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
10
30
50
70
FILTRATE VOLUME, ml


PEAT SLURRY DEWATERABILITY TEST# S2
t/V, min./ml
0.33
0.32
0.31
0.3
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
10
30
50
70
FILTRATE VOLUME, ml


PEAT SLURRY DEWATERABILITY TEST# S3
t/V, min./ml
0.36
0.35
0.34
0.33
0.32
0.31
0.3
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
10
30
50
70
FILTRATE VOLUME, ml


PEAT SLURRY DEWATERABILITY TEST# S4
t/V, min./ml
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
10
30
50
70
FILTRATE VOLUME, ml


PEAT SLURRY DEWATERABILITY TEST# SNP
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
t/V, min./ml
10
30
50
70
FILTRATE VOLUME, ml

APPENDIX I

SITE PHOTOS

Figure I-1 View of Peatland Prior to Test.

Figure I-2 Aerial View of Test Site

Figure I-3 - Slurry Pump in Working Position (Sump).

Figure I-4 General View of the Mining Operation.

Figure I-5 Peat Slurry Preparation by Hydromonitors.

Figure I-6 Relocation of Hydromonitor.

Figure I-7 Control Valve Station.

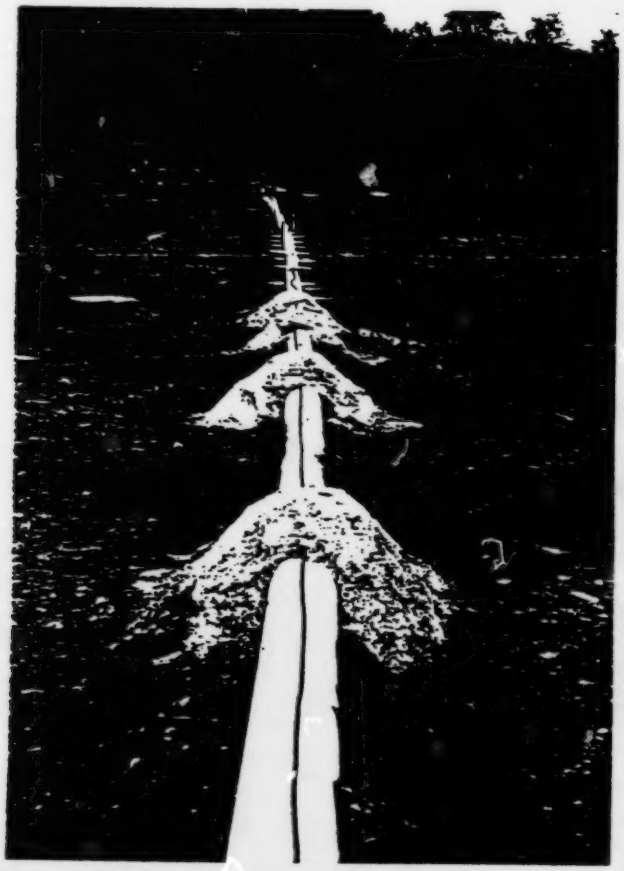


Figure I-8 Peat Slurry Pipeline.

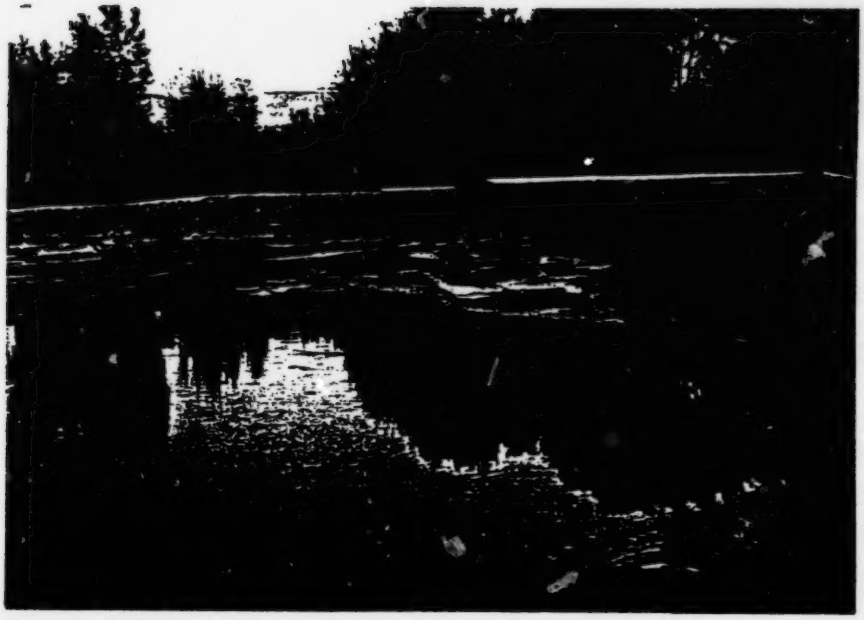


Figure I-9 Peat Slurry Reservoir.

Figure I-10 Taking a Peat Slurry Sample from the Sump.

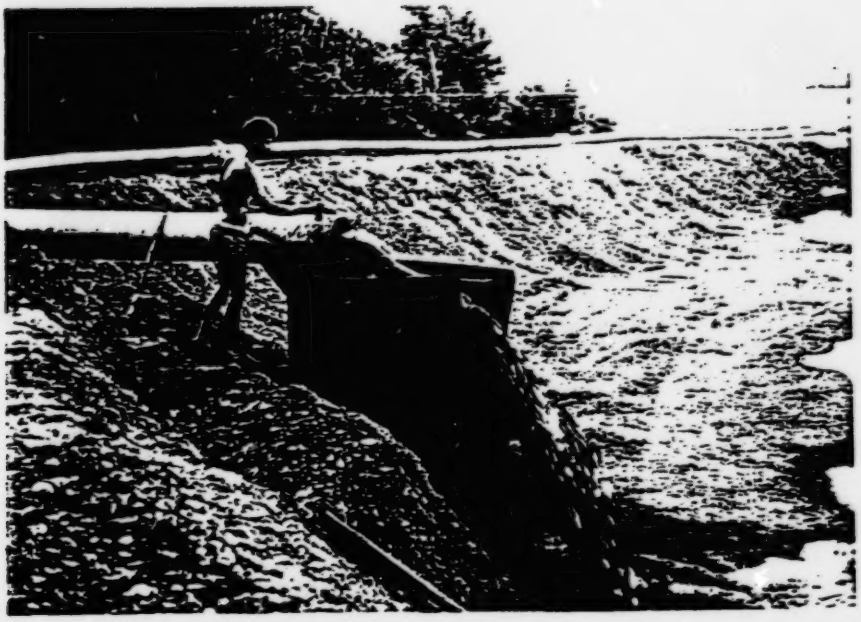


Figure I-11 Taking Peat Slurry Samples for Laboratory Analysis.

Figure I-12 Peat Slurry Analysis in the Field Laboratory.